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Supporting Information

Nickel-Catalyzed Alkyl–Alkyl Cross-Couplings of Fluorinated Secondary Electrophiles: A General Approach to the Synthesis of Compounds having a Perfluoroalkyl Substituent**

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Supporting Information

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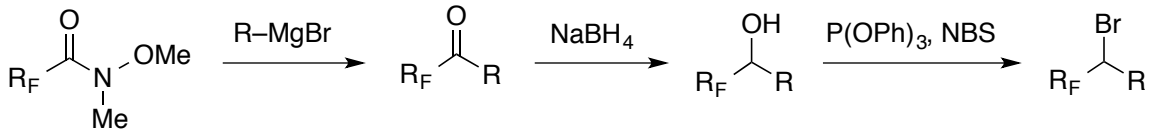
I. General Information

^{1}H NMR data and ^{13}C NMR data were collected on a VARIAN 500 MHz spectrometer at ambient temperature. ^{19}F NMR data and ^{31}P NMR data were collected on a VARIAN 300 MHz spectrometer at ambient temperature.

Anhydrous THF, CH_2Cl_2, and toluene were purified and dried using a solvent-purification system that contained activated alumina. The following reagents were purchased and used as received: $NiCl_2$·glyme (Strem), ligand **1** (Aldrich), DMA (Aldrich; anhydrous), zinc powder (Alfa-Aesar; ~100 mesh, 99.9%), iodine (Alfa-Aesar; crystalline, 99.5%), $NaBH_4$ (Oakwood), triphenyl phosphite (Aldrich), *N*-bromosuccinimide (Aldrich), *N*-iodosuccinimide (AK Scientific), oxalyl chloride (Aldrich), DMSO (Aldrich; ≥99.5%), Et_3N (Aldrich), trifluoromethyltrimethylsilane (Oakwood), TBAF (Aldrich; 1.0 M in THF), triphenylphosphine (Oakwood), and tetrabromomethane (TCI). NaBr (Aldrich; ≥99%; granular) was dried at 140 °C for 12 h prior to use. All alkyl bromides were purchased (Aldrich, Alfa Aesar, TCI, and Oakwood) and used as received.

All reactions were carried out in oven-dried glassware under an inert atmosphere.

II. Preparation of Electrophiles

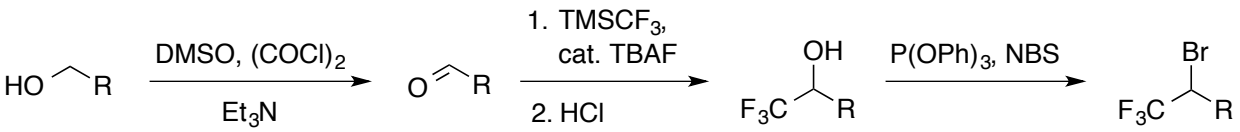


General Procedure A: Synthesis of Electrophiles with a Perfluoroalkyl Group

Preparation of the ketone using a Grignard reagent. A solution of the Grignard reagent in THF (1.0 M, 40 mmol; 1.0 equiv) was added by syringe to a solution of the Weinreb amide[1] (40 mmol) in THF (20 mL) at 0 °C. The reaction mixture was stirred at 0 °C for 15 min, and then it was allowed to warm to r.t. and stirred for 15 h. Next, water was added to quench the reaction at 0 °C. A solution of 1 N HCl (50 mL) was added, and then the mixture was extracted with CH_2Cl_2 (3 × 50 mL). The organic layers were combined, dried over Na_2SO_4, and concentrated. The crude product was purified by flash chromatography on silica gel.

Reduction of the ketone to the alcohol. $NaBH_4$ (2.3 g, 60 mmol; 3.0 equiv) was added in portions to a solution of the ketone (20 mmol) in Et_2O (20 mL) and MeOH (20 mL) at 0 °C (CAUTION: very exothermic). After the addition was complete, the mixture was stirred at 0 °C for 30 min, and then it was allowed to warm to r.t. and stirred for 30 min. Next, Et_2O (30 mL) was added to dilute the reaction mixture, the mixture was cooled to 0 °C, and then deionized water (30 mL) was added to quench the reaction. The mixture was extracted with CH_2Cl_2 (3 × 50 mL), and the combined organic layers were dried over Na_2SO_4 and concentrated. The crude product was purified by flash chromatography on silica gel.

Bromination of the alcohol.[2] Triphenylphosphite (4.0 g, 3.4 mL; 1.3 equiv) was added over 5 min to a solution of *N*-bromosuccinimide (2.3 g, 13 mmol; 1.3 equiv) in CH_2Cl_2 (10 mL) at 0 °C (CAUTION: exothermic). Next, a solution of the alcohol (10 mmol) in CH_2Cl_2 (12 mL) was added to the mixture at 0 °C. The reaction mixture was heated to 40 °C and then stirred at 40 °C for 12 h. Next, the solvent was evaporated, and the product was purified by flash chromatography on silica gel.



General Procedure B: Synthesis of Electrophiles with a CF_3 Group

Swern oxidation of the alcohol. DMSO (2.9 mL, 40 mmol; 2.0 equiv) was added slowly to a solution of oxalyl chloride (2.0 mL, 24 mmol; 1.2 equiv) in CH_2Cl_2 (150 mL) at −78 °C. The resulting mixture was allowed to stir at −78 °C for 30 min. Next, a solution of the alcohol (20

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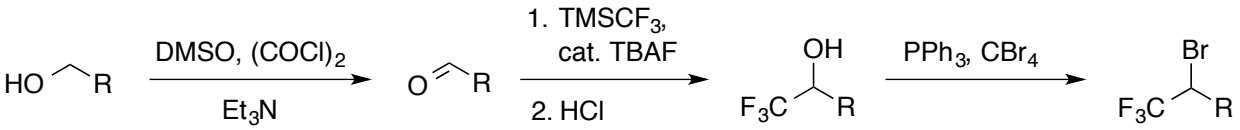
(1) Prepared from the corresponding acid anhydride, acid chloride, or ester, based on published procedures: (a) Regan, J. et al. *J. Med. Chem.* **2006**, *49*, 7887–7896. (b) Bergeron, M.; Johnson, T.; Paquin, J.-F. *Angew. Chem. Int. Ed.* **2011**, *50*, 11112–11116.

(2) Bose, A. K.; Lal, B. *Tetrahedron Lett.* **1973**, *14*, 3937–3940.

mmol) in CH_2Cl_2 (30 mL) was added over 5 min to the mixture. The resulting mixture was stirred at −78 °C for 45 min, and then NEt_3 (11 mL, 80 mmol; 4.0 equiv) was added in one portion. The mixture was allowed to warm to r.t., and then it was stirred at r.t. for 2 h. Next, an aqueous saturated solution of NH_4Cl (30 mL) was added to quench the reaction. The resulting mixture was extracted with CH_2Cl_2 (3 × 70 mL), and the combined organic layers were dried over Na_2SO_4 and concentrated. The crude product was purified by flash chromatography on silica gel.

Trifluoromethylation of the aldehyde.[3] A solution of TBAF (1.0 M in THF; 0.20 mL, 0.20 mmol; 0.013 equiv) was added over 3 min to a solution of the aldehyde (15 mmol) and trifluoromethyltrimethylsilane (2.7 mL, 18 mmol; 1.2 equiv) in THF (20 mL) at 0 °C (CAUTION: very exothermic). The reaction mixture was allowed to warm to r.t., and it was stirred for 1 h. Next, an aqueous solution of 1 N HCl (30 mL) was added, and the mixture was allowed to stir at r.t. for another 2 h. Then, the mixture was extracted with CH_2Cl_2 (3 × 50 mL), and the combined organic layers were dried over Na_2SO_4 and concentrated. The crude product was purified by flash chromatography on silica gel.

The bromination step is the same as in General Procedure A.



General Procedure C: Synthesis of Electrophiles with a CF_3 Group

The first two steps are the same as in General Procedure B.

Bromination of the alcohol.[4] Triphenylphosphine (4.2 g, 16 mmol; 2.0 equiv) and tetrabromomethane (5.3 g, 16 mmol; 2.0 equiv) were added to a solution of the alcohol (8.0 mmol) in toluene (20 mL). The resulting mixture was heated to 110 °C and stirred at 110 °C for 3 h, at which time it had turned into a yellow suspension. Then, CH_2Cl_2 (50 mL) was added to the reaction mixture until it became a clear solution. The solvents were then evaporated, and the crude product was purified by flash chromatography on silica gel.

(3) Krishnamurti, R.; Bellew, D. R.; Prakash, G. K. S. *J. Org. Chem.* **1991**, *56*, 984–989.

(4) Lin, X.; Zheng, F.; Qing, F.-L. *Organometallics* **2012**, *31*, 1578–1582.

III. Nickel-Catalyzed Alkyl–Alkyl Cross-Couplings

General procedure for the preparation of alkylzinc solutions (0.50 M).[5] In the air, zinc powder (589 mg, 9.00 mmol; 1.50 equiv) was added to an oven-dried 20-mL vial equipped with a stir bar. The vial was heated at 80 °C under high vacuum for 30 min. After back-filling with nitrogen, iodine chips (76 mg, 0.30 mmol; 0.050 equiv) were added to the vial. Then, the vial was evacuated and back-filled with nitrogen (three cycles). DMA (5 mL) was added to the mixture, and the mixture was stirred until the red color had faded. Next, the alkyl bromide (6.0 mmol; 1.0 equiv) was added. The reaction mixture was stirred at 80 °C for 12 h, and then the mixture was allowed to cool to r.t. The gray solution was filtered under an inert atmosphere by injection through a syringe filter directly into a nitrogen-filled, 20-mL vial sealed with a PTFE septum cap. The alkylzinc solution was titrated using I_2 according to Knochel's method[6] (the concentration was ~0.9 M). This solution was diluted into a 0.50 M solution by the addition of DMA.

These solutions of organozinc bromides can be stored at r.t. under an inert atmosphere for several weeks without deterioration.

General Procedure: Cross-Coupling. In the air, the electrophile (0.80 mmol) and NaBr (82 mg, 0.80 mmol; 1.0 equiv) were added to an oven-dried 20-mL vial equipped with a stir bar. The vial was closed with a PTFE septum cap and then evacuated and back-filled with nitrogen (three cycles). In the air, $NiCl_2$·glyme (17.6 mg, 0.080 mmol) and ligand **1** (26.5 mg, 0.088 mmol) were added to an oven-dried 4-mL vial equipped with a stir bar. The vial was closed with a PTFE septum cap and then evacuated and back-filled with nitrogen (three cycles). DMA (2.0 mL) was added to the 4-mL vial, and the mixture was vigorously stirred at r.t. for 25 min. The resulting solution was transferred via syringe to the 20-mL reaction vial that contained the electrophile. The 4-mL vial was rinsed with DMA three times (0.7 mL, 0.7 mL, and 0.6 mL), and the washings were transferred to the 20-mL reaction vial. The resulting solution was allowed to stir at r.t. for 1 min. Then, the reaction vial was wrapped with electrical tape, and the alkylzinc solution (0.50 M; 1.9 mL, 0.95 mmol; 1.2 equiv) was added over 1 min. The mixture was stirred vigorously at r.t. for 5 h. Then, the reaction was quenched by the addition of MeOH (0.5 mL). The resulting mixture was allowed to stir for 1 min, and then it was diluted with Et_2O (100 mL) and washed with deionized water (20 mL × 4). The organic layer was dried over Na_2SO_4 and then concentrated, and the residue was purified by flash chromatography.

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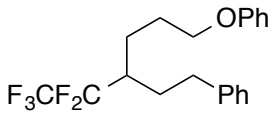
(5) (a) Huo, S. *Org. Lett.* **2003**, *5*, 423–425. (b) Son, S.; Fu, G. C. *J. Am. Chem. Soc.* **2008**, *130*, 2756–2757.

(6) Krasovskiy, A.; Knochel, P. *Synthesis* **2006**, 890–891.



((5,5,6,6,6-Pentafluoro-4-phenethylhexyl)oxy)benzene (Table 2, Entry 1). The title compound was prepared according to the General Procedure with (3-bromo-4,4,5,5,5-pentafluoropentyl)benzene (254 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from (3-bromopropoxy)benzene. Solvent system for chromatography: 10:1 → 3:1 hexane/dichloromethane. The title compound was isolated as a colorless oil.

Run 1, 217 mg (73% yield); Run 2, 220 mg (74% yield).

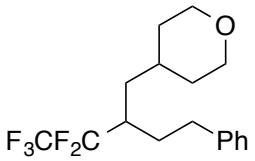
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.33 – 7.29 (m, 4H), 7.25 – 7.17 (m, 3H), 6.99 – 6.95 (m, 1H), 6.93 – 6.89 (m, 2H), 3.96 (t, 2H, *J* = 5.8 Hz), 2.81 – 2.67 (m, 2H), 2.30 – 2.17 (m, 1H), 2.13 – 2.02 (m, 1H), 1.98 – 1.69 (m, 5H);

^{13}C NMR (126 MHz, $CDCl_3$) δ 158.8, 141.0, 129.5, 128.6, 128.3, 126.2, 121.0 – 115.1 (m), 120.8, 114.4, 67.1, 39.6 (t, *J* = 19.9 Hz), 32.9, 28.5, 26.3, 23.4;

^{19}F NMR (282 MHz, $CDCl_3$) δ −81.7 (s, 3F), −117.0 (d, 2F, *J* = 16.1 Hz);

FT-IR (film) 2960, 1601, 1587, 1497, 1472, 1246, 1203, 1171, 754, 700, 692 cm^{-1};

GC-MS (EI) *m*/*z* (M^+) calcd for $C_{20}H_{21}F_5O$: 372, found: 372.



4-(3,3,4,4,4-Pentafluoro-2-phenethylbutyl)tetrahydro-2*H*-pyran (Table 2, Entry 2). The title compound was prepared according to the General Procedure with (3-bromo-4,4,5,5,5-pentafluoropentyl)benzene (254 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from 4-(bromomethyl)tetrahydro-2*H*-pyran. Solvent system for chromatography: 15:1 → 12:1 hexane/ethyl acetate. The title compound was isolated as a colorless oil.

Run 1, 147 mg (55% yield); Run 2, 144 mg (54% yield).

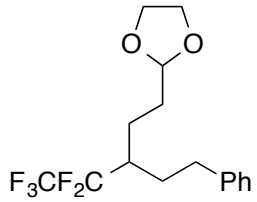
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.34 – 7.28 (m, 2H), 7.24 – 7.16 (m, 3H), 3.96 – 3.87 (m, 2H), 3.38 – 3.30 (m, 1H), 3.28 – 3.19 (m, 1H), 2.76 – 2.64 (m, 2H), 2.26 – 2.14 (m, 1H), 2.11 – 2.00 (m, 1H), 1.76 – 1.66 (m, 1H), 1.64 – 1.43 (m, 3H), 1.42 – 1.23 (m, 3H), 1.20 – 1.09 (m, 1H);

^{13}C NMR (126 MHz, $CDCl_3$) δ 141.0, 128.6, 128.4, 126.3, 121.6 – 114.0 (m), 67.8, 67.7, 36.5 (t, *J* = 19.9 Hz), 34.5, 33.5, 33.2, 32.5, 32.3, 29.7;

^{19}F NMR (282 MHz, $CDCl_3$) δ −81.4 (s, 3F), −116.2 – −118.3 (m, 2F);

FT-IR (film) 2934, 2843, 1455, 1201, 1108, 700 cm^{-1};

GC-MS (EI) *m*/*z* (M^+) calcd for $C_{17}H_{21}F_5O$: 336, found: 336.



2-(4,4,5,5,5-Pentafluoro-3-phenethylpentyl)-1,3-dioxolane (Table 2, Entry 3). The title compound was prepared according to the General Procedure with (3-bromo-4,4,5,5,5-pentafluoropentyl)benzene (254 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from 2-(2-bromoethyl)-1,3-dioxolane. Solvent system for chromatography: 10:1 → 4:1 hexane/ethyl acetate. The title compound was isolated as a colorless oil.

Run 1, 166 mg (61% yield); Run 2, 161 mg (60% yield).

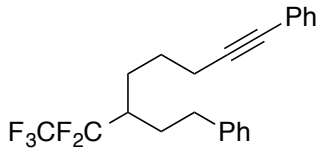
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.33 – 7.28 (m, 2H), 7.24 – 7.17 (m, 3H), 4.86 (t, 1H, *J* = 4.3 Hz), 4.02 – 3.94 (m, 2H), 3.91 – 3.83 (m, 2H), 2.75 (ddd, 1H, *J* = 13.8, 10.6, 5.7 Hz), 2.67 (ddd, 1H, *J* = 13.7, 10.4, 6.2 Hz), 2.29 – 2.16 (m, 1H), 2.02 (ddt, 1H, *J* = 19.6, 10.8, 5.1 Hz), 1.92 – 1.62 (m, 5H);

^{13}C NMR (126 MHz, $CDCl_3$) δ 141.1, 128.5, 128.3, 126.2, 121.2 – 116.1 (m), 103.9, 64.97, 64.94, 39.6 (t, *J* = 19.9 Hz), 32.8, 30.6, 28.5, 20.7;

^{19}F NMR (282 MHz, $CDCl_3$) δ −81.7 (s, 3F), −117.1 (d, 2F, *J* = 16.1 Hz);

FT-IR (film) 2958, 2885, 1203, 1143, 1096, 1008, 700 cm^{-1};

GC-MS (EI) *m*/*z* (M^+) calcd for $C_{16}H_{19}F_5O_2$: 338, found: 338.



(6-(Perfluoroethyl)oct-1-yne-1,8-diyl)dibenzene (Table 2, Entry 4). The title compound was prepared according to the General Procedure with (3-bromo-4,4,5,5,5-pentafluoropentyl)benzene (254 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from (5-bromopent-1-yn-1-yl)benzene. Solvent system for chromatography: 20:1 → 15:1 hexane/dichloromethane. The title compound was isolated as a colorless oil.

Run 1, 173 mg (57% yield); Run 2, 183 mg (60% yield).

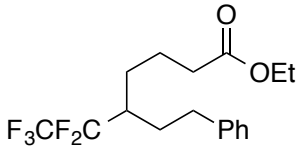
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.43 – 7.38 (m, 2H), 7.33 – 7.28 (m, 5H), 7.25 – 7.18 (m, 3H), 2.82 – 2.67 (m, 2H), 2.44 (t, 2H, *J* = 6.6 Hz), 2.27 – 2.14 (m, 1H), 2.06 (dddd, 1H, *J* = 14.8, 10.7, 6.4, 4.4 Hz), 1.93 (ddt, 1H, *J* = 13.0, 8.2, 4.1 Hz), 1.86 – 1.62 (m, 4H);

^{13}C NMR (126 MHz, $CDCl_3$) δ 141.0, 131.5, 128.5, 128.3, 128.2, 127.7, 126.2, 123.7, 121.5 – 115.0 (m), 89.1, 81.4, 39.5 (t, *J* = 20.0 Hz), 32.9, 28.5, 25.9, 25.7, 19.4;

^{19}F NMR (282 MHz, $CDCl_3$) δ −81.7 (s, 3F), −117.0 (d, 2F, *J* = 16.2 Hz);

FT-IR (film) 3028, 2959, 1490, 1454, 1202, 1171, 1122, 1094, 1008, 756, 692 cm^{-1};

GC-MS (EI) *m*/*z* (M^+) calcd for $C_{22}H_{21}F_5$: 380, found: 380.



Ethyl 6,6,7,7,7-pentafluoro-5-phenethylheptanoate (Table 2, Entry 5). The title compound was prepared according to the General Procedure with (3-bromo-4,4,5,5,5-pentafluoropentyl)benzene (254 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from ethyl 4-bromobutanoate. Solvent system for chromatography: 2:1 → 1:1.5 hexane/dichloromethane. The title compound was isolated as a colorless oil.

Run 1, 192 mg (68% yield); Run 2, 180 mg (64% yield).

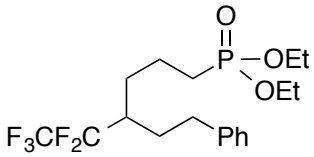
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.33 – 7.28 (m, 2H), 7.24 – 7.17 (m, 3H), 4.15 (q, 2H, J = 7.1 Hz), 2.78 – 2.64 (m, 2H), 2.31 (t, 2H, J = 6.8 Hz), 2.21 – 2.08 (m, 1H), 2.06 – 1.99 (m, 1H), 1.85 – 1.51 (m, 5H), 1.27 (t, 3H, J = 7.1 Hz);

^{13}C NMR (126 MHz, $CDCl_3$) δ 173.0, 141.0, 128.5, 128.3, 126.2, 121.1 – 114.8 (m), 60.4, 39.7 (t, J = 20.0 Hz), 34.1, 32.9, 28.5, 26.2, 22.0, 14.2;

^{19}F NMR (282 MHz, $CDCl_3$) δ −81.7 (s, 3F), −117.1 (d, 2F, J = 16.2 Hz);

FT-IR (film) 2963, 1735, 1201, 1123, 1095, 1007, 753, 700 cm^{-1};

GC-MS (EI) m/z (M^+) calcd for $C_{17}H_{21}F_5O_2$: 352, found: 352.



Diethyl (5,5,6,6,6-pentafluoro-4-phenethylhexyl)phosphonate (Table 2, Entry 6). The title compound was prepared according to the General Procedure with (3-bromo-4,4,5,5,5-pentafluoropentyl)benzene (254 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from diethyl (3-bromopropyl)phosphonate. Solvent system for chromatography: 1:1 → 1:2.5 hexane/ethyl acetate. The title compound was isolated as a colorless oil.

Run 1, 237 mg (71% yield); Run 2, 230 mg (69% yield).

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.32 – 7.27 (m, 2H), 7.23 – 7.15 (m, 3H), 4.16 – 4.03 (m, 4H), 2.75 – 2.63 (m, 2H), 2.17 – 2.07 (m, 1H), 2.05 – 1.96 (m, 1H), 1.84 – 1.56 (m, 7H), 1.32 (t, 6H, J = 7.1 Hz);

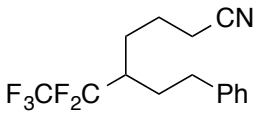
^{13}C NMR (126 MHz, $CDCl_3$) δ 140.9, 128.5, 128.3, 126.2, 121.2 – 114.7 (m), 61.6 (d, J = 6.6 Hz), 39.7 (t, J = 20.0 Hz), 32.9, 28.5, 27.6 (d, J = 16.7 Hz), 25.7 (d, J = 141.8 Hz), 20.0 (d, J = 4.9 Hz), 16.4 (d, J = 6.0 Hz);

^{19}F NMR (282 MHz, $CDCl_3$) δ −81.7 (s, 3F), −116.9 (t, 2F, J = 16.9 Hz);

^{31}P NMR (121 MHz, $CDCl_3$) δ 31.2;

FT-IR (film) 2981, 1244, 1203, 1169, 1058, 1031, 960, 701 cm^{-1};

GC-MS (EI) m/z (M^+) calcd for $C_{18}H_{26}F_5O_3P$: 416, found: 416.



6,6,7,7,7-Pentafluoro-5-phenethylheptanenitrile (Table 2, Entry 7). The title compound was prepared according to the General Procedure with (3-bromo-4,4,5,5,5-pentafluoropentyl)benzene (254 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from 4-bromobutanenitrile. Solvent system for chromatography: 10:1 → 3:1 hexane/ethyl acetate. The title compound was isolated as a yellow oil.

Run 1, 190 mg (78% yield); Run 2, 183 mg (75% yield).

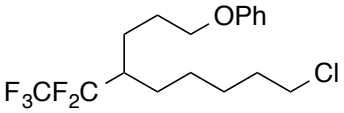
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.34 – 7.30 (m, 2H), 7.25 – 7.21 (m, 1H), 7.20 – 7.17 (m, 2H), 2.80 – 2.64 (m, 2H), 2.35 – 2.29 (m, 2H), 2.22 – 2.02 (m, 2H), 1.90 – 1.64 (m, 5H);

^{13}C NMR (126 MHz, $CDCl_3$) δ 140.4, 128.6, 128.3, 126.4, 120.5 – 114.8 (m), 118.9, 39.3 (t, J = 20.1 Hz), 32.8, 28.3, 26.0, 22.6, 17.3;

^{19}F NMR (282 MHz, $CDCl_3$) δ −81.7 (s, 3F), −116.3 (dd, 1F, J = 274.0, 15.2 Hz), −117.6 (dd, 1F, J = 273.9, 16.4 Hz);

FT-IR (film) 2952, 2247, 1497, 1455, 1335, 1203, 1173, 1124, 1096, 1007, 753, 701 cm^{-1};

GC-MS (EI) m/z (M^+) calcd for $C_{15}H_{16}F_5N$: 305, found: 305.



((9-Chloro-4-(perfluoroethyl)nonyl)oxy)benzene (Table 2, Entry 8). The title compound was prepared according to the General Procedure with 3-bromo-8-chloro-1,1,1,2,2-pentafluorooctane (254 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from (3-bromopropoxy)benzene. Solvent system for chromatography: 10:1 → 8:1 hexane/dichloromethane. The title compound was isolated as a colorless oil.

Run 1, 188 mg (63% yield); Run 2, 192 mg (64% yield).

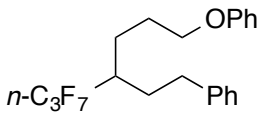
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.32 – 7.27 (m, 2H), 6.97 – 6.94 (m, 1H), 6.92 – 6.88 (m, 2H), 4.01 – 3.94 (m, 2H), 3.53 (t, 2H, J = 6.6 Hz), 2.23 – 2.12 (m, 1H), 1.95 – 1.62 (m, 7H), 1.56 – 1.33 (m, 5H);

^{13}C NMR (126 MHz, $CDCl_3$) δ 158.8, 129.5, 120.8, 119.6 – 115.9 (m), 114.4, 67.2, 44.9, 40.2 (t, J = 19.8 Hz), 32.3, 26.9, 26.6, 26.5, 26.1, 23.4;

^{19}F NMR (282 MHz, $CDCl_3$) δ −81.7 (s, 3F), −117.2 (dd, 2F, J = 16.2, 13.2 Hz);

FT-IR (film) 2954, 2871, 1601, 1587, 1498, 1471, 1246, 1202, 1018, 755, 692 cm^{-1};

GC-MS (EI) m/z (M^+) calcd for $C_{17}H_{22}ClF_5O$: 372, found: 372.



(4,4,5,5,6,6,6-Heptafluoro-3-(3-phenoxypropyl)hexyl)benzene (Table 3, Entry 1). The title compound was prepared according to the General Procedure with (3-bromo-4,4,5,5,6,6,6-heptafluorohexyl)benzene (294 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared

from (3-bromopropoxy)benzene. Solvent system for chromatography: 10:1 → 3:1 hexane/dichloromethane. The title compound was isolated as a colorless oil.

Run 1, 220 mg (65% yield); Run 2, 220 mg (65% yield).

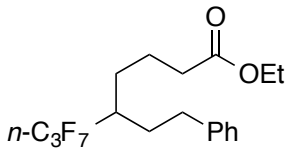
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.33 – 7.28 (m, 4H), 7.25 – 7.17 (m, 3H), 6.99 – 6.95 (m, 1H), 6.93 – 6.89 (m, 2H), 3.99 – 3.94 (m, 2H), 2.79 (ddd, 1H, *J* = 13.8, 10.4, 5.7 Hz), 2.70 (ddd, 1H, *J* = 13.7, 10.2, 6.2 Hz), 2.39 – 2.24 (m, 1H), 2.14 – 2.04 (m, 1H), 2.00 – 1.72 (m, 5H);

^{13}C NMR (126 MHz, $CDCl_3$) δ 158.8, 141.0, 129.5, 128.6, 128.4, 126.2, 121.1 – 109.7 (m), 120.8, 114.4, 67.2, 39.9 (t, *J* = 20.1 Hz), 32.9, 28.5, 26.3, 23.3;

^{19}F NMR (282 MHz, $CDCl_3$) δ −80.7 (t, 3F, *J* = 11.0 Hz), −114.1 – −114.4 (m, 2F), −124.6 – −124.8 (m, 2F);

FT-IR (film) 3029, 2952, 1601, 1498, 1226, 1173, 1111, 753, 699, 692 cm^{-1};

GC-MS (EI) *m*/*z* (M^+) calcd for $C_{21}H_{21}F_7O$: 422, found: 422.



Ethyl 6,6,7,7,8,8,8-heptafluoro-5-phenethyloctanoate (Table 3, Entry 2). The title compound was prepared according to the General Procedure with (3-bromo-4,4,5,5,6,6,6-heptafluorohexyl)benzene (294 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from ethyl 4-bromobutanoate. Solvent system for chromatography: 2:1 → 1:1.5 hexane/dichloromethane. The title compound was isolated as a colorless oil.

Run 1, 174 mg (54% yield); Run 2, 174 mg (54% yield).

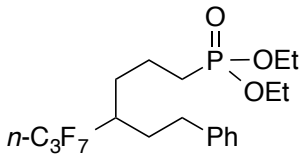
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.33 – 7.28 (m, 2H), 7.24 – 7.17 (m, 3H), 4.15 (q, 2H, *J* = 7.1 Hz), 2.79 – 2.64 (m, 2H), 2.31 (t, 2H, *J* = 6.7 Hz), 2.28 – 2.18 (m, 1H), 2.09 – 2.00 (m, 1H), 1.86 – 1.53 (m, 5H), 1.27 (t, 3H, *J* = 7.1 Hz);

^{13}C NMR (126 MHz, $CDCl_3$) δ 173.0, 141.0, 128.5, 128.3, 126.2, 121.9 – 107.1 (m), 60.4, 40.1 (t, *J* = 20.0 Hz), 34.1, 32.9, 28.5, 26.1, 22.0, 14.2;

^{19}F NMR (282 MHz, $CDCl_3$) δ −80.8 (t, 3F, *J* = 11.0 Hz), −114.1 – −114.4 (m, 2F), −124.7 – −124.8 (m, 2F);

FT-IR (film) 2963, 1736, 1225, 1178, 1107, 748, 700 cm^{-1};

GC-MS (EI) *m*/*z* (M^+) calcd for $C_{18}H_{21}F_7O_2$: 402, found: 402.



Diethyl (5,5,6,6,7,7,7-heptafluoro-4-phenethylheptyl)phosphonate (Table 3, Entry 3). The title compound was prepared according to the General Procedure with (3-bromo-4,4,5,5,6,6,6-heptafluorohexyl)benzene (294 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from diethyl (3-bromopropyl)phosphonate. Solvent system for chromatography: 1:1 → 1:2.5 hexane/ethyl acetate. The title compound was isolated as a colorless oil.

Run 1, 186 mg (50% yield); Run 2, 190 mg (51% yield).

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.32 – 7.27 (m, 2H), 7.23 – 7.15 (m, 3H), 4.16 – 4.03 (m, 4H), 2.77 – 2.62 (m, 2H), 2.28 – 2.14 (m, 1H), 2.08 – 1.98 (m, 1H), 1.88 – 1.59 (m, 7H), 1.32 (t, 6H, J = 7.1 Hz);

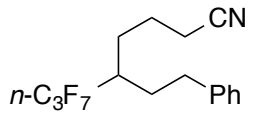
^{13}C NMR (126 MHz, $CDCl_3$) δ 140.9, 128.5, 128.3, 126.2, 121.7 – 107.0 (m), 61.6 (d, J = 6.5 Hz), 40.1 (t, J = 20.0 Hz), 32.9, 28.5, 27.6 (d, J = 17.0 Hz), 25.7 (d, J = 141.8 Hz), 19.9 (d, J = 4.8 Hz), 16.4 (d, J = 6.0 Hz);

^{19}F NMR (282 MHz, $CDCl_3$) δ −80.8 (t, 3F, J = 11.0 Hz), −114.0 – −114.3 (m, 2F), −124.6 – −124.8 (m, 2F);

^{31}P NMR (121 MHz, $CDCl_3$) δ 31.2;

FT-IR (film) 2981, 1349, 1231, 1176, 1103, 1059, 1031, 958, 749, 701 cm^{-1};

GC-MS (EI) m/z (M^+) calcd for $C_{19}H_{26}F_7O_3P$: 466, found: 466.



6,6,7,7,8,8,8-Heptafluoro-5-phenethyloctanenitrile (Table 3, Entry 4). The title compound was prepared according to the General Procedure with (3-bromo-4,4,5,5,6,6,6-heptafluorohexyl)benzene (294 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from 4-bromobutanenitrile. Solvent system for chromatography: 10:1 → 4:1 hexane/ethyl acetate. The title compound was isolated as a colorless oil.

Run 1, 200 mg (70% yield); Run 2, 190 mg (67% yield).

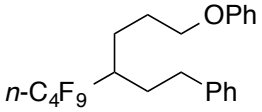
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.35 – 7.29 (m, 2H), 7.27 – 7.16 (m, 3H), 2.81 – 2.65 (m, 2H), 2.37 – 2.18 (m, 3H), 2.13 – 2.06 (m, 1H), 1.92 – 1.66 (m, 5H);

^{13}C NMR (126 MHz, $CDCl_3$) δ 140.4, 128.6, 128.3, 126.4, 121.7 – 107.5 (m), 118.9, 39.6 (t, J = 20.3 Hz), 32.9, 28.3, 26.0, 22.6, 17.3;

^{19}F NMR (282 MHz, $CDCl_3$) δ −80.7 (t, 3F, J = 11.0 Hz), −114.0 – −114.4 (m, 2F), −124.6 – −124.9 (m, 2F);

FT-IR (film) 2952, 2247, 1497, 1455, 1350, 1225, 1176, 1108, 748, 701 cm^{-1};

GC-MS (EI) m/z (M^+) calcd for $C_{16}H_{16}F_7N$: 355, found: 355.



(4,4,5,5,6,6,7,7,7-Nonafluoro-3-(3-phenoxypropyl)heptyl)benzene (Table 3, Entry 5). The title compound was prepared according to the General Procedure with (3-bromo-4,4,5,5,6,6,7,7,7-nonafluoroheptyl)benzene (334 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from (3-bromopropoxy)benzene. Solvent system for chromatography: hexane → 4:1 hexane/dichloromethane. The title compound was isolated as a colorless oil.

Run 1, 255 mg (67% yield); Run 2, 250 mg (66% yield).

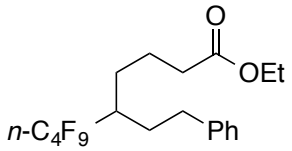
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.34 – 7.28 (m, 4H), 7.25 – 7.17 (m, 3H), 6.99 – 6.95 (m, 1H), 6.93 – 6.89 (m, 2H), 4.00 – 3.94 (m, 2H), 2.81 – 2.67 (m, 2H), 2.39 – 2.28 (m, 1H), 2.14 – 2.04 (m, 1H), 2.01 – 1.71 (m, 5H);

^{13}C NMR (126 MHz, $CDCl_3$) δ 158.8, 141.0, 129.5, 128.6, 128.3, 126.2, 121.9 – 116.0 (m), 120.8, 114.4, 67.2, 40.1 (t, J = 20.2 Hz), 32.9, 28.5, 26.3, 23.3;

^{19}F NMR (282 MHz, $CDCl_3$) δ −80.8 – −81.0 (m, 3F), −113.5 – −113.8 (m, 2F), −121.3 – −121.6 (m, 2F), −126.0 – −126.2 (m, 2F);

FT-IR (film) 3029, 2952, 1601, 1498, 1236, 1172, 1133, 752, 699, 692 cm^{-1};

GC-MS (EI) m/z (M^+) calcd for $C_{22}H_{21}F_9O$: 472, found: 472.



Ethyl 6,6,7,7,8,8,9,9,9-nonafluoro-5-phenethylnonanoate (Table 3, Entry 6). The title compound was prepared according to the General Procedure with (3-bromo-4,4,5,5,6,6,7,7,7-nonafluoroheptyl)benzene (334 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from ethyl 4-bromobutanoate. Solvent system for chromatography: hexane → 1:1.5 hexane/dichloromethane. The title compound was isolated as a colorless oil.

Run 1, 200 mg (55% yield); Run 2, 188 mg (52% yield).

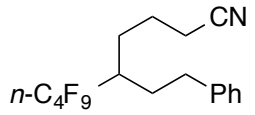
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.33 – 7.28 (m, 2H), 7.24 – 7.17 (m, 3H), 4.15 (q, 2H, J = 7.2 Hz), 2.78 – 2.65 (m, 2H), 2.34 – 2.18 (m, 3H), 2.10 – 2.00 (m, 1H), 1.86 – 1.54 (m, 5H), 1.27 (t, 3H, J = 7.1 Hz);

^{13}C NMR (126 MHz, $CDCl_3$) δ 173.0, 141.0, 128.5, 128.3, 126.2, 121.8 – 115.4 (m), 60.4, 40.3 (t, J = 20.2 Hz), 34.1, 32.9, 28.5, 26.1, 22.0, 14.2;

^{19}F NMR (282 MHz, $CDCl_3$) δ −80.8 – −81.0 (m, 3F), −113.6 – −113.9 (m, 2F), −121.4 – −121.6 (m, 2F), −126.0 – −126.3 (m, 2F);

FT-IR (film) 2963, 1735, 1235, 1133, 750, 700 cm^{-1};

GC-MS (EI) m/z (M^+) calcd for $C_{19}H_{21}F_9O_2$: 452, found: 452.



6,6,7,7,8,8,9,9,9-Nonafluoro-5-phenethylnonanenitrile (Table 3, Entry 7). The title compound was prepared according to the General Procedure with (3-bromo-4,4,5,5,6,6,7,7,7-nonafluoroheptyl)benzene (334 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from 4-bromobutanenitrile. Solvent system for chromatography: hexane → 4:1 hexane/ethyl acetate. The title compound was isolated as a colorless oil.

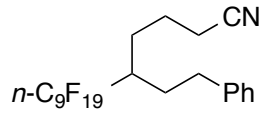
Run 1, 221 mg (68% yield); Run 2, 227 mg (70% yield).

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.35 – 7.30 (m, 2H), 7.26 – 7.21 (m, 1H), 7.21 – 7.17 (m, 2H), 2.80 – 2.65 (m, 2H), 2.37 – 2.21 (m, 3H), 2.15 – 2.05 (m, 1H), 1.92 – 1.66 (m, 5H);

^{13}C NMR (126 MHz, $CDCl_3$) δ 140.4, 128.7, 128.3, 126.4, 121.6 – 116.0 (m), 118.9, 39.8 (t, J = 20.3 Hz), 32.9, 28.3, 26.0, 22.6, 17.3;

^{19}F NMR (282 MHz, $CDCl_3$) δ −80.8 – −81.0 (m, 3F), −113.4 – −113.8 (m, 2F), −121.3 – −121.6 (m, 2F), −126.0 – −126.2 (m, 2F);

FT-IR (film) 2952, 2247, 1354, 1235, 1133, 1019, 750, 701 cm^{-1};
GC-MS (EI) *m*/*z* (M^+) calcd for $C_{17}H_{16}F_9N$: 405, found: 405.



6,6,7,7,8,8,9,9,10,10,11,11,12,12,13,13,14,14,14-Nonadecafluoro-5-phenethyltetradecanenitrile (Table 3, Entry 8). The title compound was prepared according to the General Procedure with (3-bromo-4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,12,12,12-nonadecafluorododecyl)benzene (534 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from 4-bromobutanenitrile. Solvent system for chromatography: hexane → 4:1 hexane/ethyl acetate. The title compound was isolated as a colorless viscous oil.

Run 1, 340 mg (65% yield); Run 2, 351 mg (67% yield).

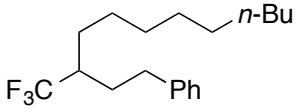
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.35 – 7.29 (m, 2H), 7.25 – 7.17 (m, 3H), 2.81 – 2.65 (m, 2H), 2.37 – 2.21 (m, 3H), 2.14 – 2.06 (m, 1H), 1.92 – 1.66 (m, 5H);

^{13}C NMR (126 MHz, $CDCl_3$) δ 140.5, 128.7, 128.3, 126.4, 120.2 – 105.1 (m), 118.9, 40.0 (t, *J* = 20.2 Hz), 32.9, 28.4, 26.0, 22.6, 17.3;

^{19}F NMR (282 MHz, $CDCl_3$) δ −80.8 (t, 3F, *J* = 10.0 Hz), −113.2 – −113.6 (m, 2F), −120.3 – −120.7 (m, 2F), −121.5 – −122.2 (m, 8F), −122.6 – −123.0 (m, 2F), −126.0 – 126.4 (m, 2F);

FT-IR (film) 2954, 2247, 1497, 1455, 1209, 1100, 739, 702, 658 cm^{-1};

GC-MS (EI) *m*/*z* ($M^+-C_9F_{19}$) calcd for $C_{13}H_{16}N$: 186, found: 186.



(3-(Trifluoromethyl)dodecyl)benzene (Table 4, Entry 1). The title compound was prepared according to the General Procedure with (3-bromo-4,4,4-trifluorobutyl)benzene (214 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from 1-bromononane. Solvent system for chromatography: hexane. The title compound was isolated as a colorless oil.

Run 1, 199 mg (79% yield); Run 2, 197 mg (78% yield).

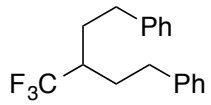
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.34 – 7.28 (m, 2H), 7.24 – 7.18 (m, 3H), 2.71 (t, 2H, *J* = 8.2 Hz), 2.12 – 2.01 (m, 1H), 1.99 – 1.89 (m, 1H), 1.80 – 1.71 (m, 1H), 1.68 – 1.59 (m, 1H), 1.52 – 1.22 (m, 15H), 0.90 (t, 3H, *J* = 6.9 Hz);

^{13}C NMR (126 MHz, $CDCl_3$) δ 141.4, 128.7 (q, *J* = 280.4 Hz), 128.5, 128.4, 126.1, 41.9 (q, *J* = 24.8 Hz), 33.1, 31.9, 29.64, 29.61, 29.5, 29.4, 29.3, 27.8 (q, *J* = 2.3 Hz), 26.7, 22.7, 14.1;

^{19}F NMR (282 MHz, $CDCl_3$) δ −69.9 (d, 3F, *J* = 9.5 Hz);

FT-IR (film) 2926, 2855, 1455, 1260, 1153, 1129, 1104, 746, 699 cm^{-1};

GC-MS (EI) *m*/*z* (M^+) calcd for $C_{19}H_{29}F_3$: 314, found: 314.



(3-(Trifluoromethyl)pentane-1,5-diyl)dibenzene (Table 4, Entry 2). The title compound was prepared according to the General Procedure with (3-bromo-4,4,4-trifluorobutyl)benzene (214 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from (2-bromoethyl)benzene. Solvent system for chromatography: hexane. The title compound was isolated as a colorless oil.

Run 1, 182 mg (78% yield); Run 2, 182 mg (78% yield).

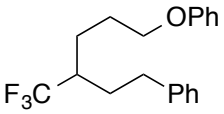
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.34 – 7.29 (m, 4H), 7.26 – 7.21 (m, 2H), 7.19 – 7.15 (m, 4H), 2.77 – 2.65 (m, 4H), 2.19 – 2.08 (m, 1H), 2.00 (dddd, 2H, J = 14.8, 9.2, 6.8, 5.7 Hz), 1.82 (ddt, 2H, J = 13.7, 9.4, 6.7 Hz);

^{13}C NMR (126 MHz, $CDCl_3$) δ 141.1, 128.58 (q, J = 281.1 Hz), 128.53, 128.4, 126.2, 41.2 (q, J = 25.0 Hz), 32.9, 29.7 (d, J = 2.4 Hz);

^{19}F NMR (282 MHz, $CDCl_3$) δ −69.7 (d, 3F, J = 9.4 Hz);

FT-IR (film) 3027, 2937, 1497, 1454, 1260, 1145, 1113, 747, 699 cm^{-1};

GC-MS (EI) m/z (M^+) calcd for $C_{18}H_{19}F_3$: 292, found: 292.



(6-Phenoxy-3-(trifluoromethyl)hexyl)benzene (Table 4, Entry 3). The title compound was prepared according to the General Procedure with (3-bromo-4,4,4-trifluorobutyl)benzene (214 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from (3-bromopropoxy)benzene. Solvent system for chromatography: 6:1 → 5:1 hexane/dichloromethane. The title compound was isolated as a colorless oil.

Run 1, 213 mg (83% yield); Run 2, 213 mg (83% yield).

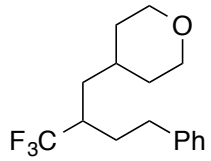
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.34 – 7.28 (m, 4H), 7.25 – 7.18 (m, 3H), 6.99 – 6.96 (m, 1H), 6.93 – 6.89 (m, 2H), 3.96 (t, 2H, J = 5.9 Hz), 2.81 – 2.69 (m, 2H), 2.21 – 2.13 (m, 1H), 2.01 (dddd, 1H, J = 14.2, 9.4, 6.7, 5.6 Hz), 1.93 – 1.69 (m, 5H);

^{13}C NMR (126 MHz, $CDCl_3$) δ 158.8, 141.1, 129.5, 128.54 (q, J = 280.3 Hz), 128.52, 128.4, 126.2, 120.7, 114.4, 67.2, 41.6 (q, J = 25.1 Hz), 32.9, 29.5 (q, J = 2.4 Hz), 26.4, 24.4 (q, J = 2.5 Hz);

^{19}F NMR (282 MHz, $CDCl_3$) δ −69.8 (d, 3F, J = 9.4 Hz);

FT-IR (film) 2953, 2874, 1601, 1497, 1246, 1152, 1120, 754, 700, 692 cm^{-1};

GC-MS (EI) m/z (M^+) calcd for $C_{19}H_{21}F_3O$: 322, found: 322.



4-(4-Phenyl-2-(trifluoromethyl)butyl)tetrahydro-2*H*-pyran (Table 4, Entry 4). The title compound was prepared according to the General Procedure with (3-bromo-4,4,4-

trifluorobutyl)benzene (214 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from 4-(bromomethyl)tetrahydro-2*H*-pyran. Solvent system for chromatography: 12:1 hexane/ethyl acetate. The title compound was isolated as a colorless oil.

Run 1, 167 mg (73% yield); Run 2, 169 mg (74% yield).

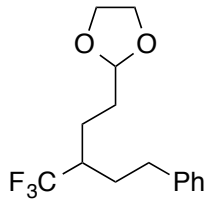
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.33 – 7.28 (m, 2H), 7.24 – 7.17 (m, 3H), 3.97 – 3.87 (m, 2H), 3.35 (td, 1H, *J* = 11.8, 2.1 Hz), 3.27 (td, 1H, *J* = 11.8, 2.3 Hz), 2.78 – 2.65 (m, 2H), 2.19 – 2.09 (m, 1H), 1.98 (ddt, 1H, *J* = 14.3, 9.2, 6.2 Hz), 1.74 – 1.66 (m, 1H), 1.59 – 1.51 (m, 3H), 1.40 – 1.12 (m, 4H);

^{13}C NMR (126 MHz, $CDCl_3$) δ 141.0, 128.6 (q, *J* = 280.2 Hz), 128.5, 128.4, 126.2, 67.82, 67.76, 38.4 (q, *J* = 25.0 Hz), 35.4 (q, *J* = 2.3 Hz), 33.2, 33.0, 32.7, 32.3, 30.2 (q, *J* = 2.3 Hz);

^{19}F NMR (282 MHz, $CDCl_3$) δ −70.3 (d, 3F, *J* = 9.2 Hz);

FT-IR (film) 2935, 2842, 1261, 1239, 1160, 1134, 1105, 700 cm^{-1};

GC-MS (EI) *m*/*z* (M^+) calcd for $C_{16}H_{21}F_3O$: 286, found: 286.



2-(5-Phenyl-3-(trifluoromethyl)pentyl)-1,3-dioxolane (Table 4, Entry 5). The title compound was prepared according to the General Procedure with (3-bromo-4,4,4-trifluorobutyl)benzene (214 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from 2-(2-bromoethyl)-1,3-dioxolane. Solvent system for chromatography: 10:1 → 6:1 hexane/ethyl acetate. The title compound was isolated as a colorless oil.

Run 1, 163 mg (71% yield); Run 2, 166 mg (72% yield).

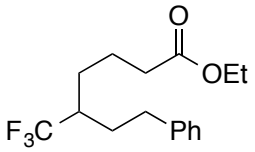
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.33 – 7.28 (m, 2H), 7.23 – 7.17 (m, 3H), 4.85 (t, 1H, *J* = 4.2 Hz), 4.01 – 3.93 (m, 2H), 3.90 – 3.82 (m, 2H), 2.78 – 2.66 (m, 2H), 2.21 – 2.09 (m, 1H), 1.96 (dddd, 1H, *J* = 14.3, 9.5, 6.8, 5.7 Hz), 1.83 – 1.70 (m, 4H), 1.69 – 1.62 (m, 1H);

^{13}C NMR (126 MHz, $CDCl_3$) δ 141.1, 128.49, 128.48 (q, *J* = 280.5 Hz), 128.3, 126.1, 103.9, 64.95, 64.92, 41.6 (q, *J* = 25.1 Hz), 32.8, 30.7, 29.5 (q, *J* = 2.3 Hz), 21.8 (q, *J* = 2.6 Hz);

^{19}F NMR (282 MHz, $CDCl_3$) δ −69.9 (d, 3F, *J* = 9.4 Hz);

FT-IR (film) 2955, 2881, 1454, 1396, 1263, 1145, 1116, 1031, 749, 700 cm^{-1};

GC-MS (EI) *m*/*z* (M^+) calcd for $C_{15}H_{19}F_3O_2$: 288, found: 288.



Ethyl 7-phenyl-5-(trifluoromethyl)heptanoate (Table 4, Entry 6). The title compound was prepared according to the General Procedure with (3-bromo-4,4,4-trifluorobutyl)benzene (214 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from ethyl 4-bromobutanoate. Solvent system for chromatography: 2:1 → 1:1.5 hexane/dichloromethane. The title compound was isolated as a colorless oil.

Run 1, 198 mg (82% yield); Run 2, 200 mg (83% yield).

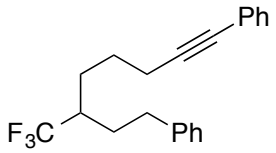
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.32 – 7.28 (m, 2H), 7.23 – 7.18 (m, 3H), 4.15 (q, 2H, J = 7.1 Hz), 2.74 – 2.68 (m, 2H), 2.30 (t, 2H, J = 7.0 Hz), 2.13 – 2.04 (m, 1H), 2.01 – 1.92 (m, 1H), 1.81 – 1.62 (m, 4H), 1.56 – 1.49 (m, 1H), 1.27 (t, 3H, J = 7.1 Hz);

^{13}C NMR (126 MHz, $CDCl_3$) δ 173.0, 141.1, 128.5, 128.4 (q, J = 280.4 Hz), 128.3, 126.2, 60.4, 41.7 (q, J = 25.0 Hz), 34.1, 32.9, 29.4 (q, J = 2.4 Hz), 27.2 (q, J = 2.5 Hz), 22.0, 14.2;

^{19}F NMR (282 MHz, $CDCl_3$) δ −69.9 (d, 3F, J = 9.4 Hz);

FT-IR (film) 2942, 1734, 1262, 1184, 1147, 1114, 748, 700 cm^{-1};

GC-MS (EI) m/z (M^+) calcd for $C_{16}H_{21}F_3O_2$: 302, found: 302.



(6-(Trifluoromethyl)oct-1-yne-1,8-diyl)dibenzene (Table 4, Entry 7). The title compound was prepared according to the General Procedure with (3-bromo-4,4,4-trifluorobutyl)benzene (214 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from (5-bromopent-1-yn-1-yl)benzene. Solvent system for chromatography: 20:1 → 15:1 hexane/dichloromethane. The title compound was isolated as a colorless oil.

Run 1, 175 mg (66% yield); Run 2, 176 mg (67% yield).

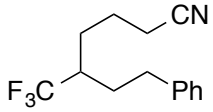
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.43 – 7.39 (m, 2H), 7.33 – 7.27 (m, 5H), 7.24 – 7.18 (m, 3H), 2.81 – 2.69 (m, 2H), 2.43 (t, 2H, J = 6.6 Hz), 2.21 – 2.08 (m, 1H), 2.00 (dddd, 1H, J = 14.2, 9.5, 6.8, 5.6 Hz), 1.89 – 1.66 (m, 5H);

^{13}C NMR (126 MHz, $CDCl_3$) δ 141.1, 131.5, 128.52 (q, J = 280.4 Hz), 128.51, 128.3, 128.2, 127.7, 126.2, 123.7, 89.2, 81.3, 41.5 (q, J = 25.0 Hz), 32.9, 29.5 (q, J = 2.4 Hz), 26.9 (q, J = 2.4 Hz), 25.7, 19.4;

^{19}F NMR (282 MHz, $CDCl_3$) δ −69.8 (d, 3F, J = 9.4 Hz);

FT-IR (film) 2951, 1490, 1262, 1146, 1114, 756, 692 cm^{-1};

GC-MS (EI) m/z (M^+) calcd for $C_{21}H_{21}F_3$: 330, found: 330.



7-Phenyl-5-(trifluoromethyl)heptanenitrile (Table 4, Entry 8). The title compound was prepared according to the General Procedure with (3-bromo-4,4,4-trifluorobutyl)benzene (214 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from 4-bromobutanenitrile. Solvent system for chromatography: 10:1 → 4:1 hexane/ethyl acetate. The title compound was isolated as a colorless oil.

Run 1, 170 mg (83% yield); Run 2, 170 mg (83% yield).

This compound was also prepared on a 6.00 mmol scale, using (3-bromo-4,4,4-trifluorobutyl)benzene (1.60 g, 6.00 mmol) and an alkylzinc bromide reagent prepared from 4-bromobutanenitrile (0.50 M; 14.4 mL, 7.20 mmol; 1.20 equiv). Following the General Procedure

using 5.0% $NiCl_2$·glyme (65.9 mg, 0.300 mmol) and 5.5% ligand **1** (99.5 mg, 0.330 mmol), the title compound was isolated in 80% yield (1.22 g).

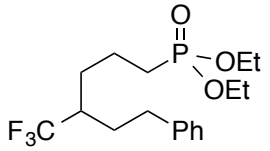
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.34 – 7.30 (m, 2H), 7.25 – 7.18 (m, 3H), 2.79 – 2.68 (m, 2H), 2.32 (t, 2H, *J* = 6.8 Hz), 2.15 – 2.06 (m, 1H), 2.02 (dddd, 1H, *J* = 14.5, 8.9, 6.9, 5.6 Hz), 1.82 – 1.62 (m, 5H);

^{13}C NMR (126 MHz, $CDCl_3$) δ 140.6, 128.6, 128.3, 128.1 (q, *J* = 280.3 Hz), 126.3, 119.0, 41.2 (q, *J* = 25.3 Hz), 32.8, 29.4 (q, *J* = 2.4 Hz), 26.9 (q, *J* = 2.5 Hz), 22.6, 17.2;

^{19}F NMR (282 MHz, $CDCl_3$) δ −69.7 (d, 3F, *J* = 9.1 Hz);

FT-IR (film) 3028, 2946, 2877, 2247, 1497, 1462, 1455, 1396, 1263, 1195, 1149, 1115, 1031, 751, 701 cm^{-1};

GC-MS (EI) *m*/*z* (M^+) calcd for $C_{14}H_{16}F_3N$: 255, found: 255.



Diethyl (6-phenyl-4-(trifluoromethyl)hexyl)phosphonate (Table 4, Entry 9). The title compound was prepared according to the General Procedure with (3-bromo-4,4,4-trifluorobutyl)benzene (214 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from diethyl (3-bromopropyl)phosphonate. Solvent system for chromatography: 4:1 → 1:3 hexane/ethyl acetate. The title compound was isolated as a colorless oil.

Run 1, 258 mg (88% yield); Run 2, 260 mg (89% yield).

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.31 – 7.26 (m, 2H), 7.22 – 7.15 (m, 3H), 4.15 – 4.02 (m, 4H), 2.70 (t, 2H, *J* = 8.1 Hz), 2.10 – 2.02 (m, 1H), 1.94 (dddd, 1H, *J* = 14.4, 8.7, 7.3, 5.8 Hz), 1.78 – 1.52 (m, 7H), 1.31 (t, 6H, *J* = 7.1 Hz);

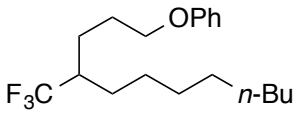
^{13}C NMR (126 MHz, $CDCl_3$) δ 140.9, 128.5, 128.34 (q, *J* = 280.3 Hz), 128.28, 126.2, 61.5 (d, *J* = 6.5 Hz), 41.6 (q, *J* = 25.4 Hz), 32.9, 29.4 (d, *J* = 2.3 Hz), 28.6 (dd, *J* = 16.7, 2.4 Hz), 25.6 (d, *J* = 141.8 Hz), 19.9 (d, *J* = 4.8 Hz), 16.4 (d, *J* = 5.9 Hz);

^{19}F NMR (282 MHz, $CDCl_3$) δ −69.8 (d, 3F, *J* = 9.3 Hz);

^{31}P NMR (121 MHz, $CDCl_3$) δ 31.3;

FT-IR (film) 2981, 2940, 1257, 1161, 1107, 1058, 1030, 960, 701 cm^{-1};

GC-MS (EI) *m*/*z* (M^+) calcd for $C_{17}H_{26}F_3O_3P$: 366, found: 366.



((4-(Trifluoromethyl)dodecyl)oxy)benzene (Table 5, Entry 1). The title compound was prepared according to the General Procedure with 2-bromo-1,1,1-trifluorodecane (220 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from (3-bromopropoxy)benzene. Solvent system for chromatography: hexane → 10:1 hexane/dichloromethane. The title compound was isolated as a colorless oil.

Run 1, 225 mg (85% yield); Run 2, 230 mg (87% yield).

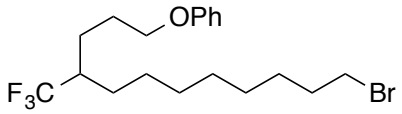
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.32 – 7.26 (m, 2H), 6.97 – 6.93 (m, 1H), 6.92 – 6.88 (m, 2H), 3.97 (t, 2H, *J* = 6.1 Hz), 2.10 (dddd, 1H, *J* = 15.7. 9.6, 6.4, 3.6 Hz), 1.94 – 1.84 (m, 2H), 1.83 – 1.73 (m, 1H), 1.71 – 1.59 (m, 2H), 1.50 – 1.23 (m, 13H), 0.90 (t, 3H, *J* = 6.9 Hz);

^{13}C NMR (126 MHz, $CDCl_3$) δ 158.9, 129.4, 128.6 (q, *J* = 280.4 Hz), 120.7, 114.4, 67.4, 42.3 (q, *J* = 24.8 Hz), 31.8, 29.7, 29.4, 29.2, 27.8 (q, *J* = 2.4 Hz), 26.8, 26.6, 24.5 (q, *J* = 2.3 Hz), 22.7, 14.1;

^{19}F NMR (282 MHz, $CDCl_3$) δ −70.1 (d, 3F, *J* = 9.5 Hz);

FT-IR (film) 2927, 2856, 1601, 1498, 1245, 1160, 1133, 753, 691 cm^{-1};

GC-MS (EI) *m*/*z* (M^+) calcd for $C_{19}H_{29}F_3O$: 330, found: 330.



((12-Bromo-4-(trifluoromethyl)dodecyl)oxy)benzene (Table 5, Entry 2). The title compound was prepared according to the General Procedure with 2,10-dibromo-1,1,1-trifluorodecane (283 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from (3-bromopropoxy)benzene. Solvent system for chromatography: 10:1 → 6:1 hexane/dichloromethane. The title compound was isolated as a colorless oil.

Run 1, 259 mg (79% yield); Run 2, 260 mg (79% yield).

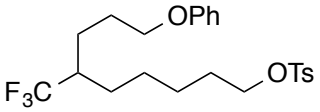
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.32 – 7.27 (m, 2H), 6.97 – 6.93 (m, 1H), 6.92 – 6.88 (m, 2H), 3.97 (t, 2H, *J* = 6.1 Hz), 3.41 (t, 2H, *J* = 6.8 Hz), 2.11 (ddtd, 1H, *J* = 15.6, 9.6, 5.9, 3.4 Hz), 1.92 – 1.73 (m, 5H), 1.71 – 1.59 (m, 2H), 1.51 – 1.25 (m, 11H);

^{13}C NMR (126 MHz, $CDCl_3$) δ 158.8, 129.4, 128.6 (q, *J* = 280.5 Hz), 120.7, 114.4, 67.3, 42.3 (q, *J* = 24.8 Hz), 34.0, 32.8, 29.5, 29.2, 28.7, 28.1, 27.8 (q, *J* = 2.5 Hz), 26.7, 26.6, 24.4 (q, *J* = 2.5 Hz);

^{19}F NMR (282 MHz, $CDCl_3$) δ −70.1 (d, 3F, *J* = 9.5 Hz);

FT-IR (film) 2931, 2856, 1601, 1498, 1245, 1162, 1121, 754, 691 cm^{-1};

GC-MS (EI) *m*/*z* (M^+) calcd for $C_{19}H_{28}{}^{79}BrF_3O$: 408, found: 408, 410 ($M^+$+2).



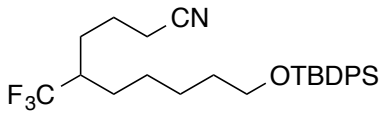
9-Phenoxy-6-(trifluoromethyl)nonyl 4-methylbenzenesulfonate (Table 5, Entry 3). The title compound was prepared according to the General Procedure with 6-bromo-7,7,7-trifluoroheptyl 4-methylbenzenesulfonate (322 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from (3-bromopropoxy)benzene. Solvent system for chromatography: 10:1 hexane/ethyl acetate. The title compound was isolated as a colorless oil.

Run 1, 275 mg (75% yield); Run 2, 278 mg (76% yield).

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.81 – 7.76 (m, 2H), 7.36 – 7.32 (m, 2H), 7.31 – 7.25 (m, 2H), 6.96 – 6.92 (m, 1H), 6.91 – 6.86 (m, 2H), 4.03 – 3.92 (m, 4H), 2.44 (s, 3H), 2.15 – 2.00 (m, 1H), 1.90 – 1.80 (m, 2H), 1.79 – 1.71 (m, 1H), 1.69 – 1.53 (m, 4H), 1.46 – 1.25 (m, 5H);

^{13}C NMR (126 MHz, $CDCl_3$) δ 158.8, 144.7, 133.1, 129.8, 129.4, 128.4 (q, *J* = 281.0 Hz), 127.8, 120.7, 114.4, 70.3, 67.2, 42.2 (q, *J* = 24.8 Hz), 28.6, 27.6 (d, *J* = 2.7 Hz), 26.5, 26.1, 25.5, 24.4 (d, *J* = 2.7 Hz), 21.6;

^{19}F NMR (282 MHz, $CDCl_3$) δ −70.0 (d, 3F, J = 9.5 Hz);
FT-IR (film) 2946, 1600, 1498, 1360, 1246, 1189, 1177, 1157, 955, 815, 756, 664 cm^{-1};
LC-MS (ESI) m/z ($M+H^+$) calcd for $C_{23}H_{30}F_3O_4S$: 459, found: 459.



10-((*tert*-Butyldiphenylsilyl)oxy)-5-(trifluoromethyl)decanenitrile (Table 5, Entry 4). The title compound was prepared according to the General Procedure with ((6-bromo-7,7,7-trifluoroheptyl)oxy)(*tert*-butyl)diphenylsilane (390 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from 4-bromobutanenitrile. Solvent system for chromatography: 10:1 → 8:1 hexane/ethyl acetate. The title compound was isolated as a colorless oil.

Run 1, 268 mg (70% yield); Run 2, 281 mg (74% yield).

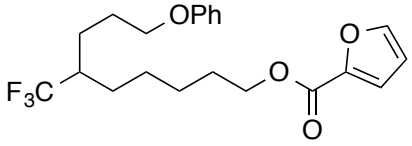
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.70 – 7.66 (m, 4H), 7.46 – 7.37 (m, 6H), 3.68 (t, 2H, J = 6.3 Hz), 2.38 – 2.33 (m, 2H), 2.08 – 2.01 (m, 1H), 1.83 – 1.68 (m, 3H), 1.68 – 1.54 (m, 4H), 1.44 – 1.33 (m, 5H), 1.06 (s, 9H);

^{13}C NMR (126 MHz, $CDCl_3$) δ 135.5, 134.0, 129.5, 128.2 (q, J = 280.3 Hz), 127.6, 119.0, 63.7, 42.1 (q, J = 25.2 Hz), 32.2, 27.7 (q, J = 2.4 Hz), 27.1 (q, J = 2.4 Hz), 26.8, 26.5, 25.8, 22.8, 19.2, 17.3;

^{19}F NMR (282 MHz, $CDCl_3$) δ −69.9 (d, 3F, J = 9.3 Hz);

FT-IR (film) 2933, 2858, 2247, 1428, 1258, 1153, 1112, 703 cm^{-1};

GC-MS (EI) m/z ($M^+-C_4H_9$) calcd for $C_{23}H_{27}F_3NOSi$: 418, found: 418.



9-Phenoxy-6-(trifluoromethyl)nonyl furan-2-carboxylate (Table 5, Entry 5). The title compound was prepared according to the General Procedure with 6-bromo-7,7,7-trifluoroheptyl furan-2-carboxylate (274 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from (3-bromopropoxy)benzene. Solvent system for chromatography: 20:1 hexane/ethyl acetate. The title compound was isolated as a colorless oil.

Run 1, 267 mg (84% yield); Run 2, 258 mg (81% yield).

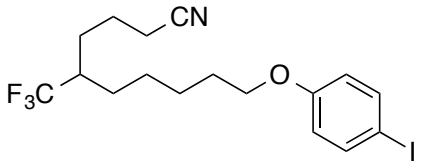
^{1}H NMR (500 MHz, CD_3COCD_3) δ 7.80 (dd, 1H, J = 1.8, 0.8 Hz), 7.30 – 7.25 (m, 2H), 7.22 (dd, 1H, J = 3.5, 0.9 Hz), 6.96 – 6.89 (m, 3H), 6.63 (dd, 1H, J = 3.5, 1.8 Hz), 4.27 (t, 2H, J = 6.6 Hz), 4.03 (t, 2H, J = 6.1 Hz), 2.38 – 2.25 (m, 1H), 1.94 – 1.64 (m, 7H), 1.60 – 1.43 (m, 5H);

^{13}C NMR (126 MHz, CD_3COCD_3) δ 160.1, 159.1, 147.9, 146.0, 130.4, 130.1 (q, J = 279.8 Hz), 121.5, 118.7, 115.5, 112.9, 68.2, 65.4, 43.0 (q, J = 24.6 Hz), 29.4, 28.6 (q, J = 2.5 Hz), 27.4, 27.3, 26.9, 25.3 (q, J = 2.7 Hz);

^{19}F NMR (282 MHz, CD_3COCD_3) δ −70.6 (d, 3F, J = 9.9 Hz);

FT-IR (film) 2948, 2871, 1722, 1601, 1586, 1498, 1475, 1398, 1297, 1246, 1180, 1120, 1078, 755, 692 cm^{-1};

GC-MS (EI) m/z (M^+) calcd for $C_{21}H_{25}F_3O_4$: 398, found: 398.



10-(4-Iodophenoxy)-5-(trifluoromethyl)decanenitrile (Table 5, Entry 6). The title compound was prepared according to the General Procedure with 1-((6-bromo-7,7,7-trifluoroheptyl)oxy)-4-iodobenzene (361 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from 4-bromobutanenitrile. Solvent system for chromatography: 10:1 → 4:1 hexane/ethyl acetate. The title compound was isolated as a white solid.

Run 1, 283 mg (81% yield); Run 2, 285 mg (81% yield).

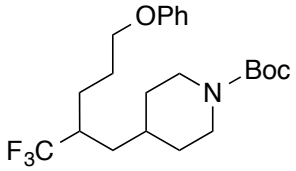
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.56 – 7.52 (m, 2H), 6.69 – 6.64 (m, 2H), 3.92 (t, 2H, J = 6.3 Hz), 2.40 – 2.35 (m, 2H), 2.14 – 2.02 (m, 1H), 1.84 – 1.59 (m, 7H), 1.51 – 1.41 (m, 5H);

^{13}C NMR (126 MHz, $CDCl_3$) δ 158.8, 138.1, 128.1 (q, J = 280.3 Hz), 119.0, 116.9, 82.5, 67.7, 42.1 (q, J = 25.3 Hz), 28.9, 27.7 (q, J = 2.4 Hz), 27.1 (q, J = 2.4 Hz), 26.5, 26.1, 22.8, 17.4;

^{19}F NMR (282 MHz, $CDCl_3$) δ −69.9 (d, 3F, J = 9.3 Hz);

FT-IR (film) 2943, 2246, 1586, 1487, 1244, 1174, 1153, 1125, 821 cm^{-1};

GC-MS (EI) m/z (M^+) calcd for $C_{17}H_{21}F_3INO$: 439, found: 439.



***tert*-Butyl 4-(5-phenoxy-2-(trifluoromethyl)pentyl)piperidine-1-carboxylate (Table 5, Entry 7).** The title compound was prepared according to the General Procedure with *tert*-butyl 4-(2-bromo-3,3,3-trifluoropropyl)piperidine-1-carboxylate (288 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from (3-bromopropoxy)benzene. Solvent system for chromatography: 25:1 → 15:1 hexane/ethyl acetate. The title compound was isolated as a colorless oil.

Run 1, 267 mg (80% yield); Run 2, 265 mg (80% yield).

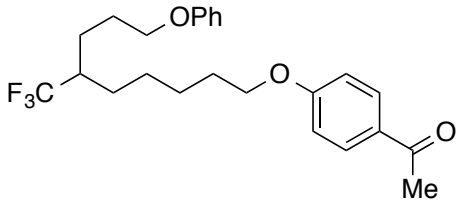
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.31 – 7.26 (m, 2H), 6.97 – 6.93 (m, 1H), 6.90 – 6.86 (m, 2H), 4.16 – 4.02 (m, 2H), 3.99 – 3.95 (m, 2H), 2.73 – 2.57 (m, 2H), 2.27 – 2.16 (m, 1H), 1.94 – 1.75 (m, 3H), 1.71 – 1.61 (m, 3H), 1.60 – 1.50 (m, 2H), 1.46 (s, 9H), 1.38 – 1.30 (m, 1H), 1.15 – 1.01 (m, 2H);

^{13}C NMR (126 MHz, $CDCl_3$) δ 158.7, 154.7, 129.5, 128.5 (q, J = 280.0 Hz), 120.8, 114.4, 79.3, 67.1, 39.2 (q, J = 25.1 Hz), 34.9, 33.4, 32.3, 31.9, 28.4, 26.4, 25.1 (d, J = 2.5 Hz);

^{19}F NMR (282 MHz, $CDCl_3$) δ −70.4 (d, 3F, J = 9.3 Hz);

FT-IR (film) 2973, 2933, 2870, 1692, 1498, 1424, 1366, 1246, 1171, 1138, 755, 692 cm^{-1};

GC-MS (EI) m/z (M^+−Boc) calcd for $C_{17}H_{23}F_3NO$: 314, found: 314.



1-(4-((9-Phenoxy-6-(trifluoromethyl)nonyl)oxy)phenyl)ethan-1-one (Table 5, Entry 8). The title compound was prepared according to the General Procedure with 1-(4-((6-bromo-7,7,7-trifluoroheptyl)oxy)phenyl)ethan-1-one (294 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from (3-bromopropoxy)benzene. Solvent system for chromatography: 10:1 → 4:1 hexane/ethyl acetate. The title compound was isolated as a yellow oil.

Run 1, 291 mg (86% yield); Run 2, 287 mg (85% yield).

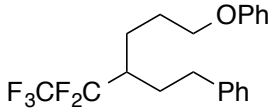
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.95 – 7.90 (m, 2H), 7.31 – 7.25 (m, 2H), 6.98 – 6.86 (m, 5H), 4.01 (t, 2H, *J* = 6.4 Hz), 3.96 (t, 2H, *J* = 6.0 Hz), 2.55 (s, 3H), 2.13 (dddd, 1H, *J* = 14.7, 8.8, 5.8, 3.1 Hz), 1.93 – 1.74 (m, 5H), 1.72 – 1.62 (m, 2H), 1.57 – 1.42 (m, 5H);

^{13}C NMR (126 MHz, $CDCl_3$) δ 196.7, 163.0, 158.8, 130.6, 130.2, 129.4, 128.5 (q, *J* = 280.4 Hz), 120.7, 114.4, 114.1, 67.9, 67.3, 42.2 (q, *J* = 25.0 Hz), 28.9, 27.7 (d, *J* = 2.3 Hz), 26.6, 26.5, 26.3, 26.1, 24.5 (d, *J* = 2.5 Hz);

^{19}F NMR (282 MHz, $CDCl_3$) δ −70.0 (d, 3F, *J* = 9.5 Hz);

FT-IR (film) 2945, 1676, 1601, 1254, 1172, 1158, 1124, 834, 755, 692 cm^{-1};

LC-MS (ESI) *m*/*z* ($M+H^+$) calcd for $C_{24}H_{30}F_3O_3$: 423, found: 423.



((5,5,6,6,6-Pentafluoro-4-phenethylhexyl)oxy)benzene (eq 5). The title compound was prepared according to the General Procedure with (4,4,5,5,5-pentafluoro-3-iodopentyl)benzene (291 mg, 0.80 mmol) and an alkylzinc bromide reagent prepared from (3-bromopropoxy)benzene. Solvent system for chromatography: 10:1 → 3:1 hexane/dichloromethane. The title compoundwas isolated as a colorless oil.

Run 1, 186 mg (62% yield); Run 2, 183 mg (61% yield).

For the characterization data, see Table 2, Entry 1 (above).

Competition Experiments (Table 6). In a nitrogen-filled glovebox, $NiCl_2$·glyme (2.2 mg, 0.010 mmol), ligand **1** (3.3 mg, 0.011 mmol), and NaBr (10.3 mg, 0.10 mmol) were added to an oven-dried 4-mL vial equipped with a stir bar. DMA (0.25 mL) was added to the 4-mL vial, and the vial was closed with a PTFE septum cap. The mixture was vigorously stirred at r.t. for 25 min. Then, a solution in DMA of each of the two alkyl electrophiles (0.10 mmol in 0.25 mL of DMA) was added in turn to the 4-mL vial. The combined mixture was allowed to stir at r.t. for 1 min. Next, the solution of the alkylzinc reagent (0.50 M; 0.24 mL, 0.12 mmol; 1.2 equiv) was added in one portion. The reaction mixture was stirred vigorously at r.t. for 10 min, and then the reaction was quenched with MeOH (0.2 mL). A solution of $PhCF_3$ (0.20 M; 0.50 mL, 0.10 mmol; 1.0 equiv) in $CDCl_3$ was added to the vial as an internal standard, and the reaction

mixture was analyzed by ^{19}F NMR spectroscopy. When (3-bromobutyl)benzene was used as the electrophile, *n*-tetradecane (26 μL) was added to the vial as another internal standard, and the reaction mixture was also analyzed by GC.

Study of the effect of TEMPO:

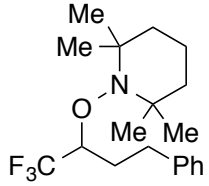
Eq 6, without TEMPO: In a nitrogen-filled glovebox, $NiCl_2$·glyme (2.2 mg, 0.010 mmol), ligand **1** (3.3 mg, 0.011 mmol), and NaBr (10.3 mg, 0.10 mmol) were added to an oven-dried 4-mL vial equipped with a stir bar. DMA (0.25 mL) was added to the 4-mL vial, and the vial was closed with a PTFE septum cap. The mixture was stirred vigorously at r.t. for 25 min. Then, a solution of the alkyl electrophile in DMA (0.10 mmol in 0.25 mL of DMA) was added to this solution. The resulting solution was allowed to stir at r.t. for 1 min. Next, a solution of the alkylzinc reagent (0.50 M; 0.24 mL, 0.12 mmol; 1.2 equiv) was added in one portion. The mixture was stirred vigorously at r.t. for 2 min, and then the reaction was quenched with MeOH (0.2 mL). A solution of $PhCF_3$ (0.20 M; 0.50 mL, 0.10 mmol; 1.0 equiv) in $CDCl_3$ was added to the vial as an internal standard, and the reaction mixture was analyzed by ^{19}F NMR spectroscopy.

Eq 6, with TEMPO: In a nitrogen-filled glovebox, (3-bromo-4,4,4-trifluorobutyl)benzene (26.7 mg, 0.10 mmol) and NaBr (10.3 mg, 0.10 mmol) were added to an oven-dried 4-mL vial equipped with a stir bar. DMA (0.25 mL) was added to this vial, and then a solution of TEMPO in DMA (0.15 M; 0.10 mL, 0.015 mmol; 0.15 equiv) and a solution of the alkylzinc reagent (0.50 M; 0.24 mL, 0.12 mmol; 1.2 equiv).

In a nitrogen-filled glove box, $NiCl_2$·glyme (6.6 mg, 0.030 mmol) and ligand **1** (9.9 mg, 0.033 mmol) were added to a second oven-dried 4-mL vial equipped with a stir bar. DMA (0.75 mL) was added to this vial, and the vial was closed with a PTFE septum cap. The mixture was vigorously stirred at r.t. for 25 min. Next, 0.25 mL of this catalyst stock solution was added to the 4-mL reaction vial in one portion. The resulting mixture was stirred vigorously at r.t. for 2 min, and then the reaction was quenched with MeOH (0.2 mL). A solution of $PhCF_3$ (0.20 M; 0.50 mL, 0.10 mmol; 1.0 equiv) in $CDCl_3$ was added to the vial as an internal standard, and the reaction mixture was analyzed by ^{19}F NMR spectroscopy.

Eq 7: In a nitrogen-filled glovebox, (3-bromo-4,4,4-trifluorobutyl)benzene (26.7 mg, 0.10 mmol) and NaBr (10.3 mg, 0.10 mmol) were added to an oven-dried 4-mL vial equipped with a stir bar. DMA (0.25 mL) was added to this vial, and then a solution of TEMPO in DMA (0.15 M; 0.10 mL, 0.015 mmol; 0.15 equiv) and a solution of the alkylzinc reagent (0.50 M; 0.24 mL, 0.12 mmol; 1.2 equiv)..

In a nitrogen-filled glove box, $NiCl_2$·glyme (6.6 mg, 0.030 mmol) and ligand **1** (9.9 mg, 0.033 mmol) were added to a second oven-dried 4-mL vial equipped with a stir bar. DMA (0.75 mL) was added to this vial, and the vial was closed with a PTFE septum cap. The mixture was vigorously stirred at r.t. for 25 min. Next, 0.25 mL of this catalyst stock solution was added to the 4-mL reaction vial in one portion. The resulting mixture was stirred vigorously at r.t. for 15 min, and then the reaction was quenched with MeOH (0.2 mL). A solution of $PhCF_3$ (0.20 M; 0.50 mL, 0.10 mmol; 1.0 equiv) in $CDCl_3$ was added to the vial as an internal standard, and the reaction mixture was analyzed by ^{19}F NMR spectroscopy.



2,2,6,6-Tetramethyl-1-((1,1,1-trifluoro-4-phenylbutan-2-yl)oxy)piperidine (eq 7; preparation of an authentic sample). The title compound was prepared according to the General Procedure with (3-bromo-4,4,4-trifluorobutyl)benzene (267 mg, 1.00 mmol) and an alkylzinc bromide reagent prepared from 1-bromononane, in the presence of TEMPO (94 mg, 0.40 mmol), $NiCl_2$·glyme (88 mg, 0.40 mmol), and ligand **1** (133 mg, 0.44 mmol). Solvent system for chromatography: hexane → 7:1 hexane/dichloromethane. The title compound was isolated as a colorless oil (98 mg, 71% yield).

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.33 – 7.28 (m, 2H), 7.24 – 7.19 (m, 3H), 4.32 – 4.24 (m, 1H), 2.84 (ddd, 1H, *J* = 16.2, 11.4, 5.0 Hz), 2.75 (ddd, 1H, *J* = 14.0, 10.6, 6.5 Hz), 2.49 – 2.40 (m, 1H), 2.07 – 1.97 (m, 1H), 1.67 – 1.40 (m, 5H), 1.37 – 1.28 (m, 1H), 1.21 – 1.06 (m, 12H);

^{13}C NMR (126 MHz, $CDCl_3$) δ 141.3, 128.44, 128.36, 126.0, 125.3 (q, *J* = 283.3 Hz), 79.5 (q, *J* = 27.5 Hz), 61.1, 60.2, 40.5, 33.9, 33.4, 31.6 (d, *J* = 1.7 Hz), 29.8 (d, *J* = 1.3 Hz), 20.3, 17.1;

^{19}F NMR (282 MHz, $CDCl_3$) δ −73.3 (d, 3F, *J* = 6.9 Hz);

FT-IR (film) 2976, 2933, 2873, 1457, 1378, 1363, 1264, 1189, 1159, 1132, 1090, 748, 698 cm^{-1};

HRMS (ESI) *m*/*z* ($M+H^+$) calcd for $C_{19}H_{29}F_3NO$: 344.2201, found: 344.2194.

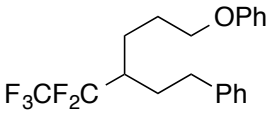
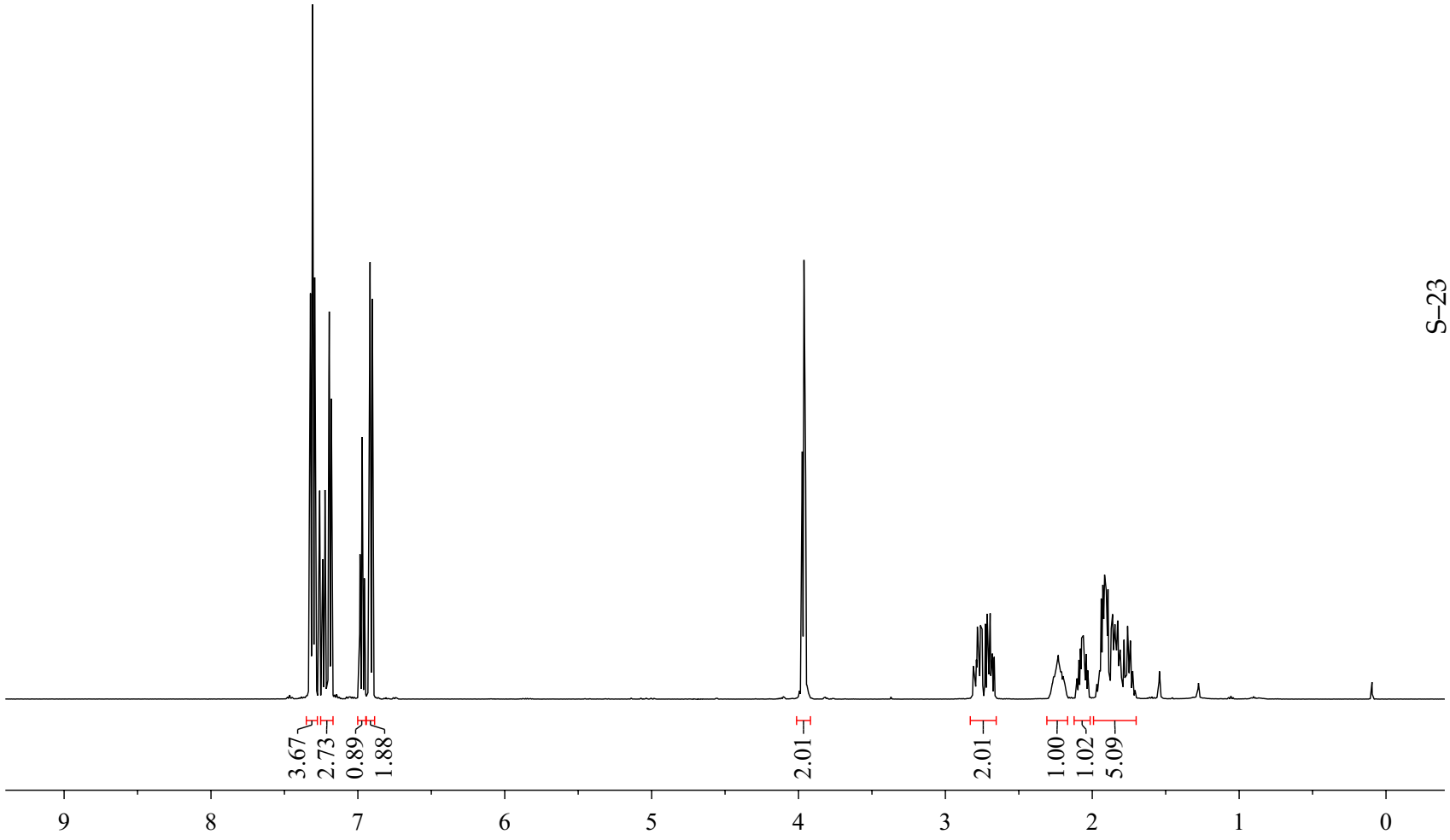


Table 2, Entry 1
($CDCl_3$, 500 MHz)

IV. ^{1}H NMR Spectra



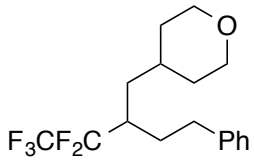
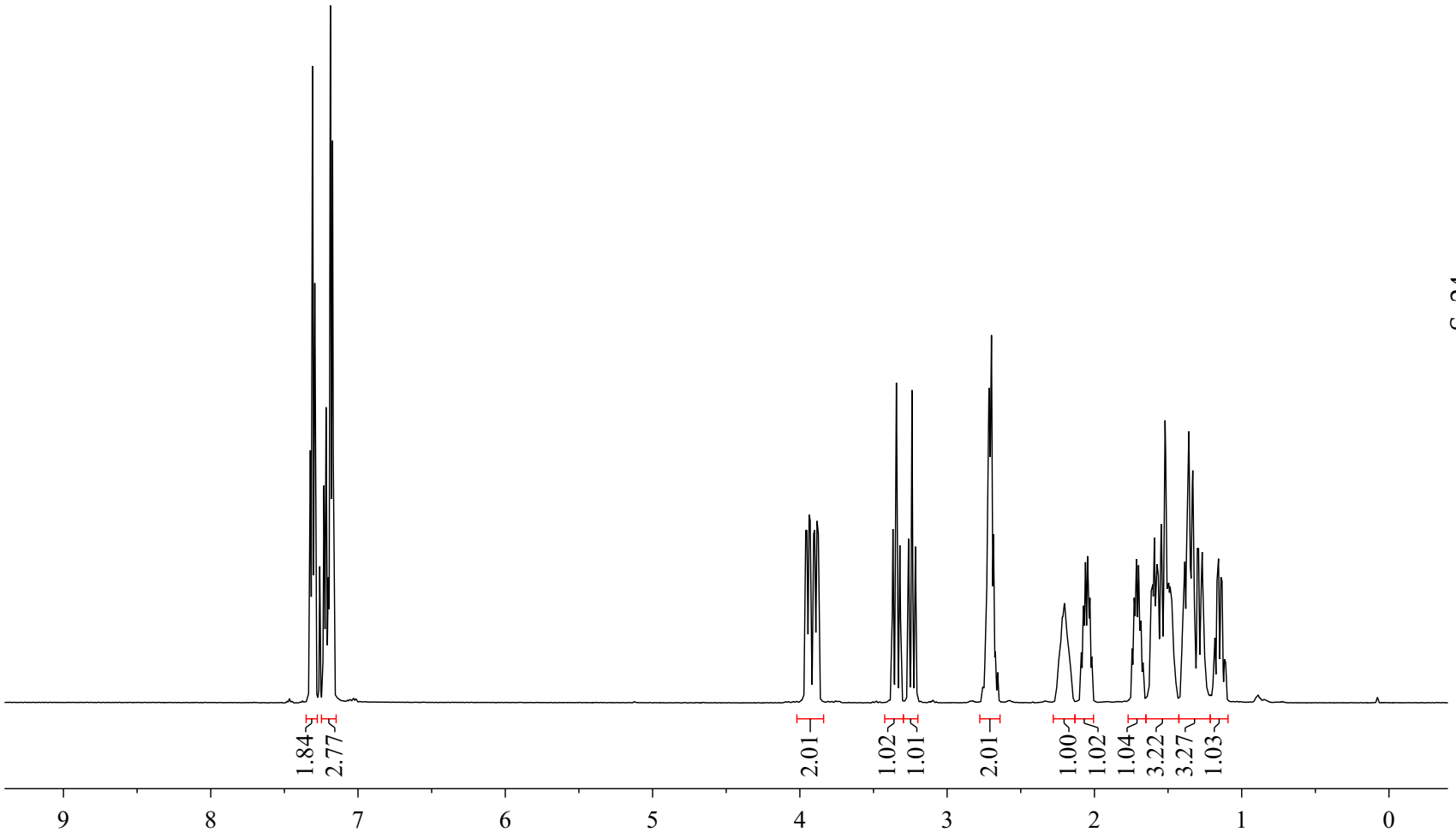


Table 2, Entry 2
($CDCl_3$, 500 MHz)



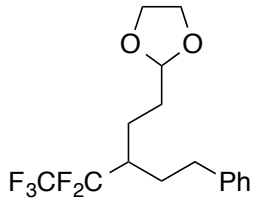
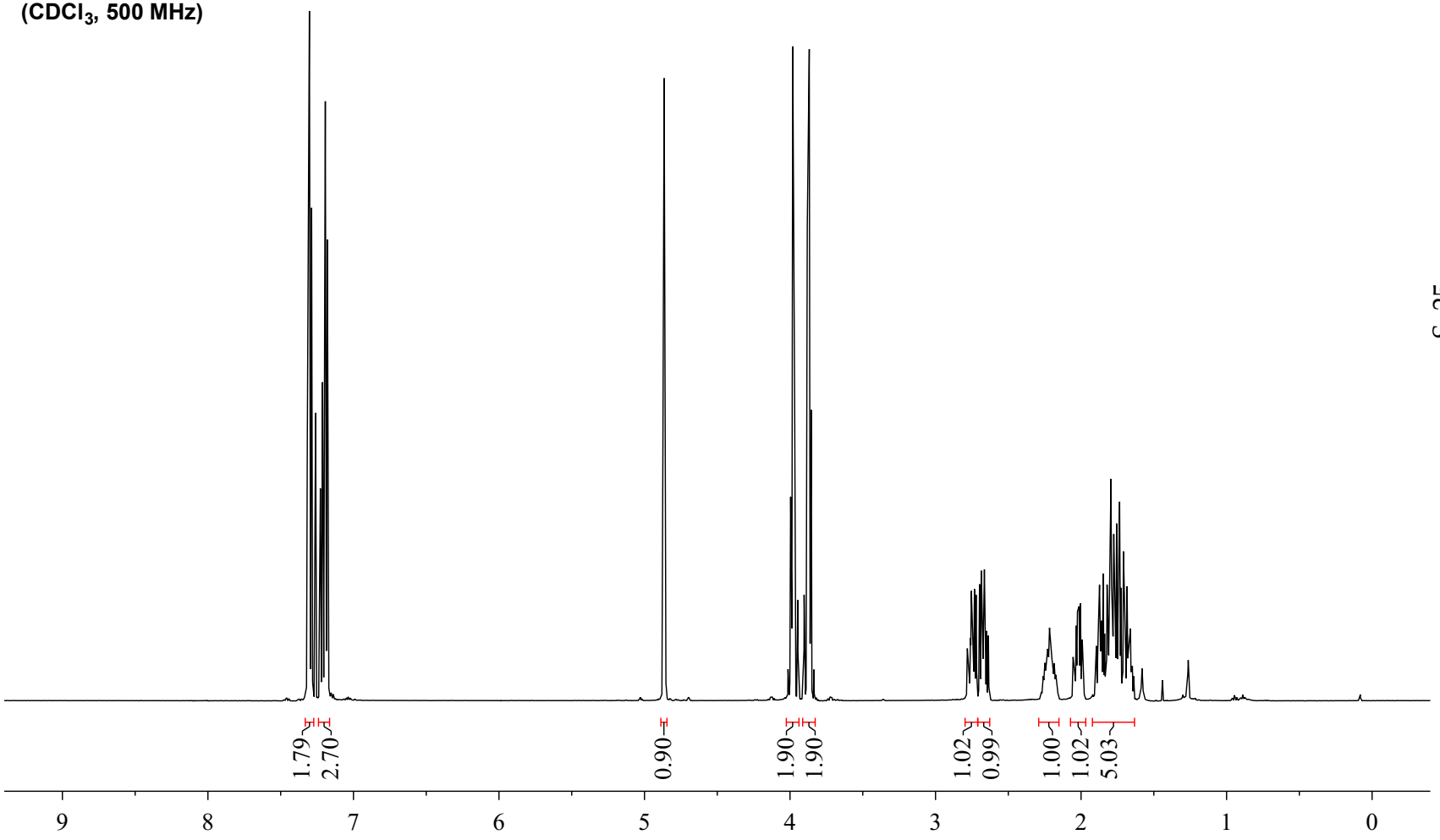


Table 2, Entry 3
($CDCl_3$, 500 MHz)



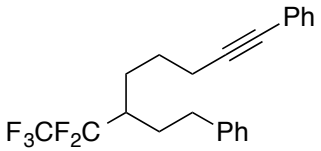
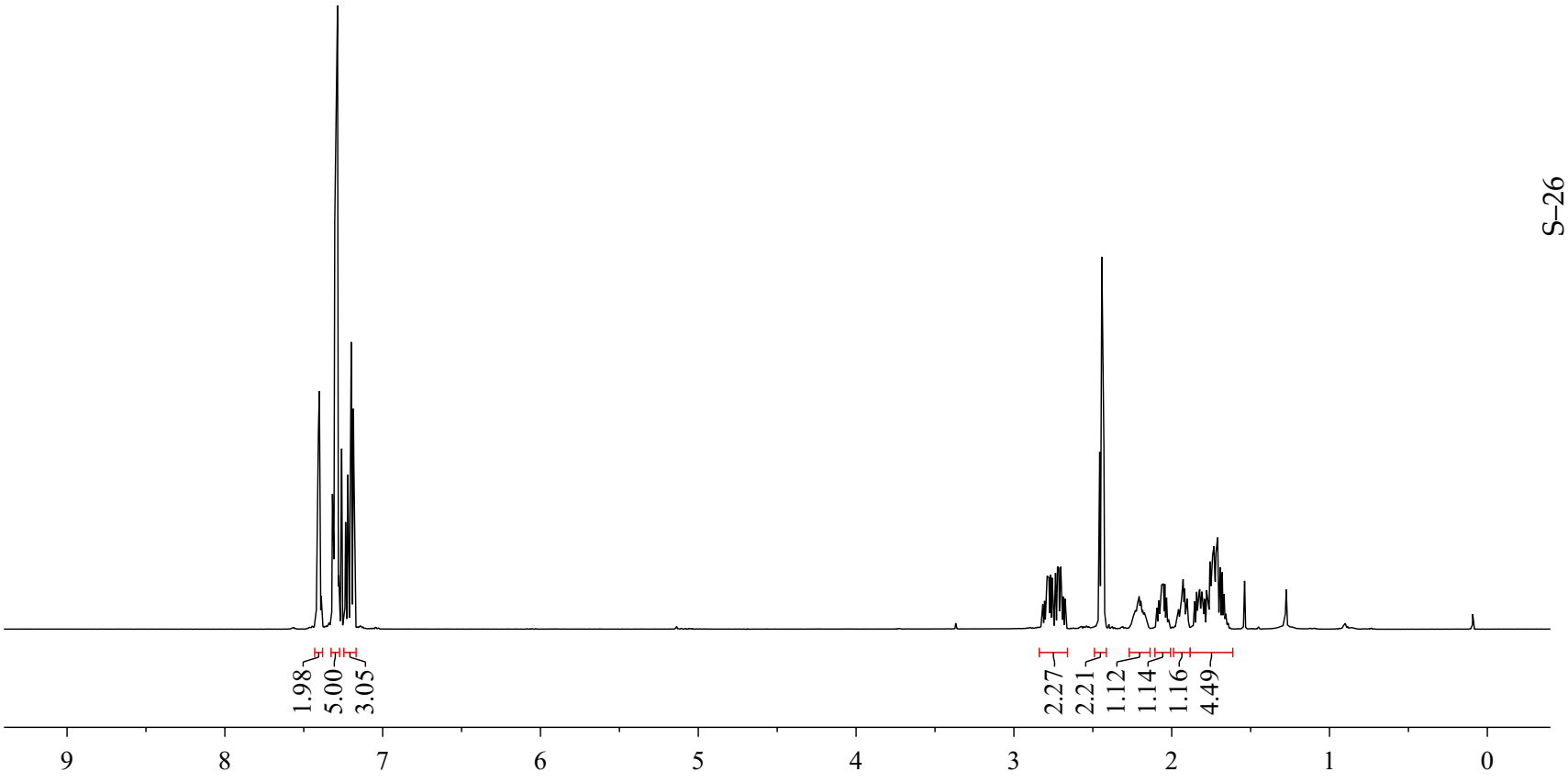


Table 2, Entry 4
($CDCl_3$, 500 MHz)



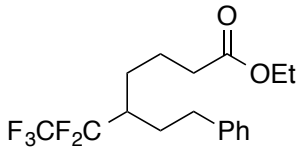


Table 2, Entry 5
($CDCl_3$, 500 MHz)

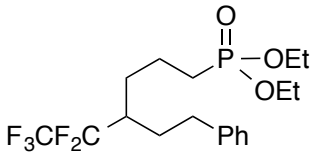
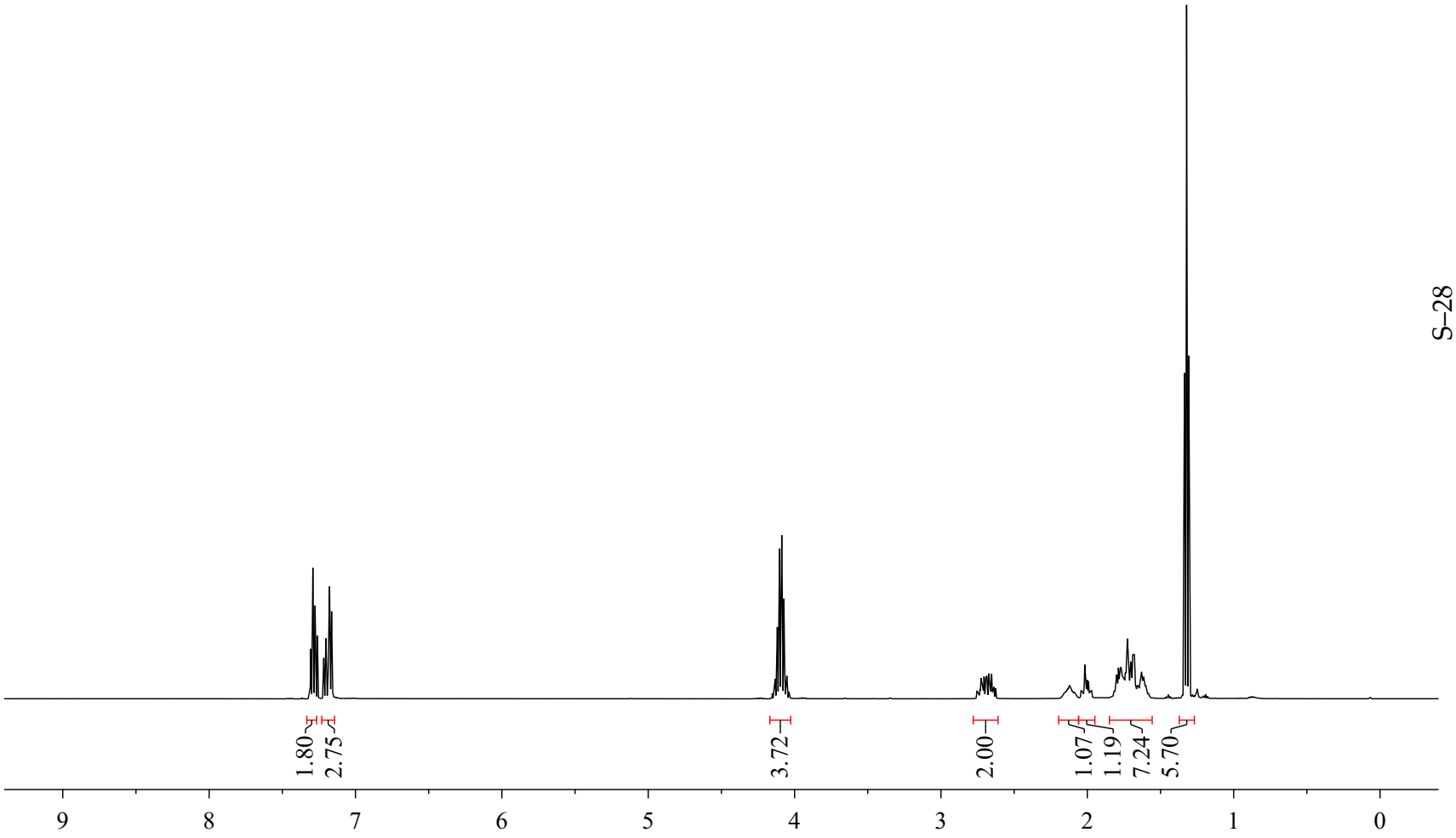


Table 2, Entry 6
($CDCl_3$, 500 MHz)



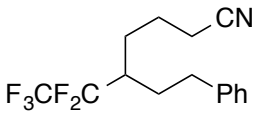
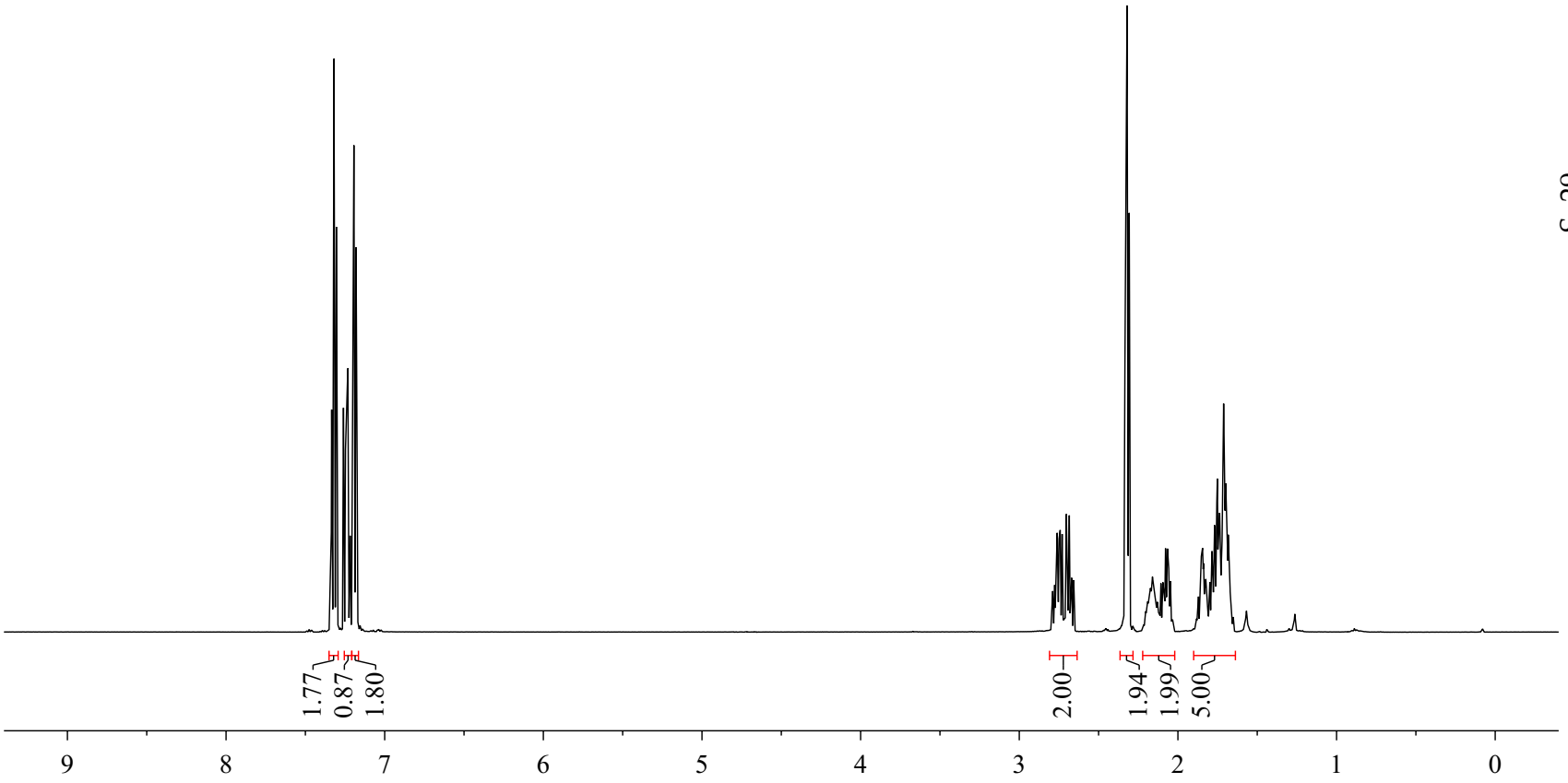


Table 2, Entry 7
($CDCl_3$, 500 MHz)



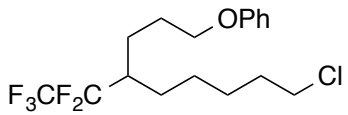
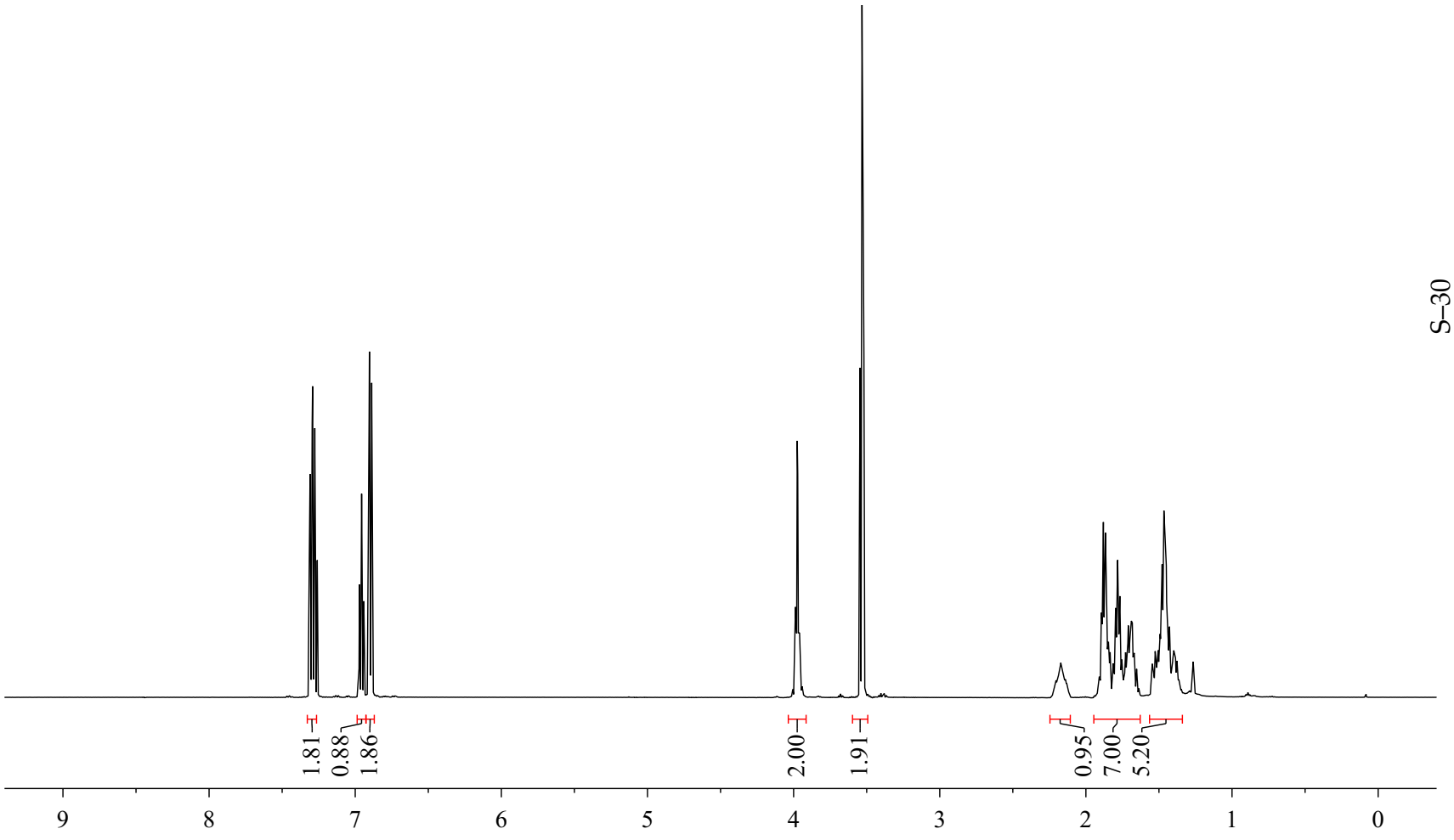


Table 2, Entry 8
($CDCl_3$, 500 MHz)



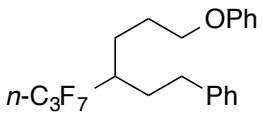
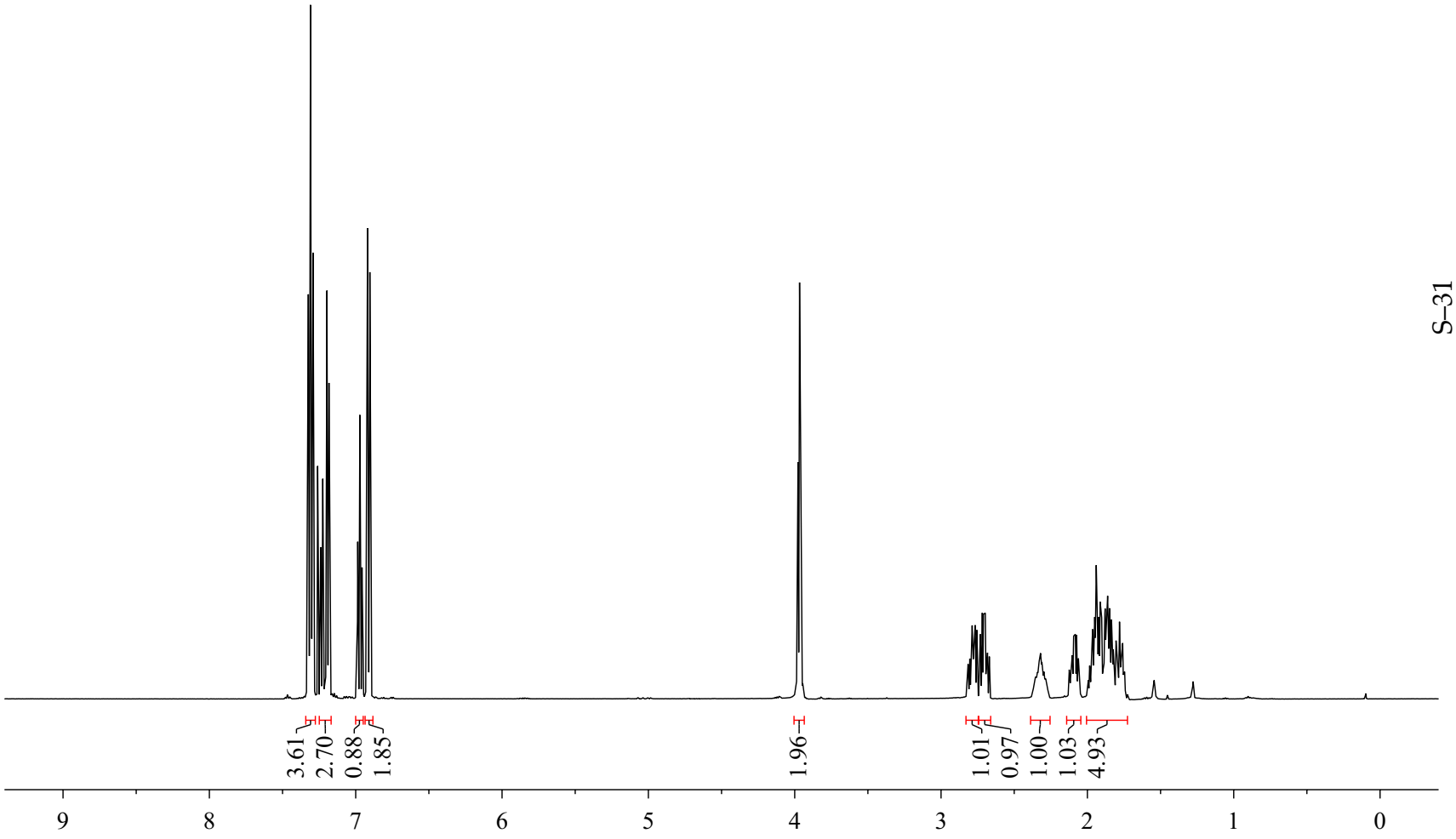


Table 3, Entry 1
($CDCl_3$, 500 MHz)



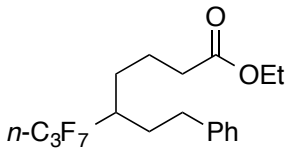


Table 3, Entry 2
($CDCl_3$, 500 MHz)

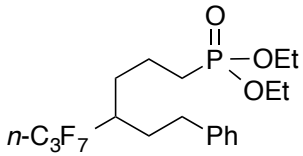


Table 3, Entry 3
($CDCl_3$, 500 MHz)

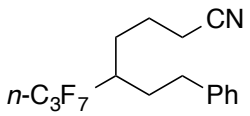
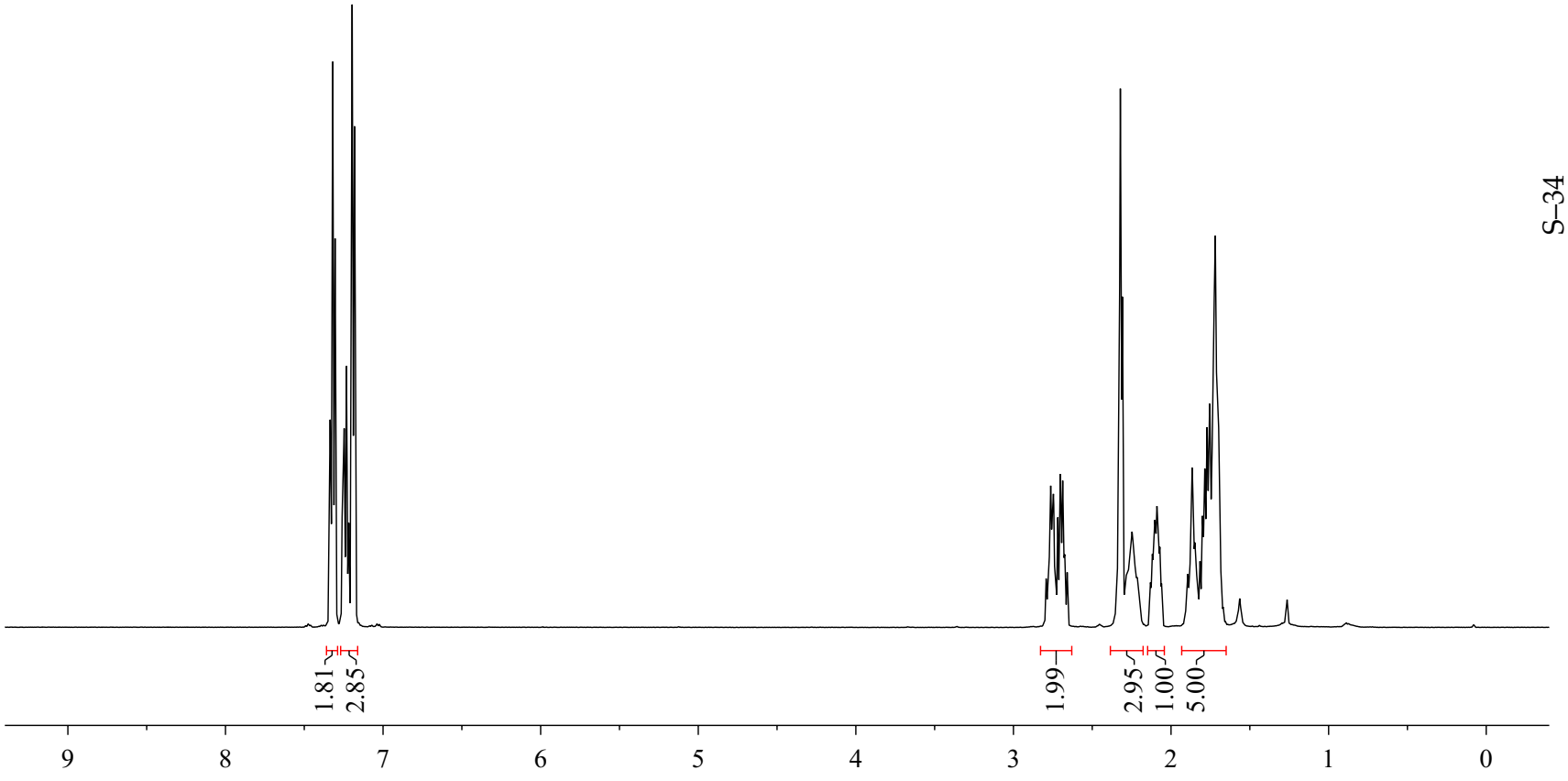


Table 3, Entry 4
($CDCl_3$, 500 MHz)



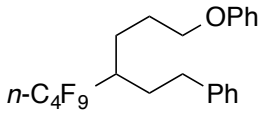
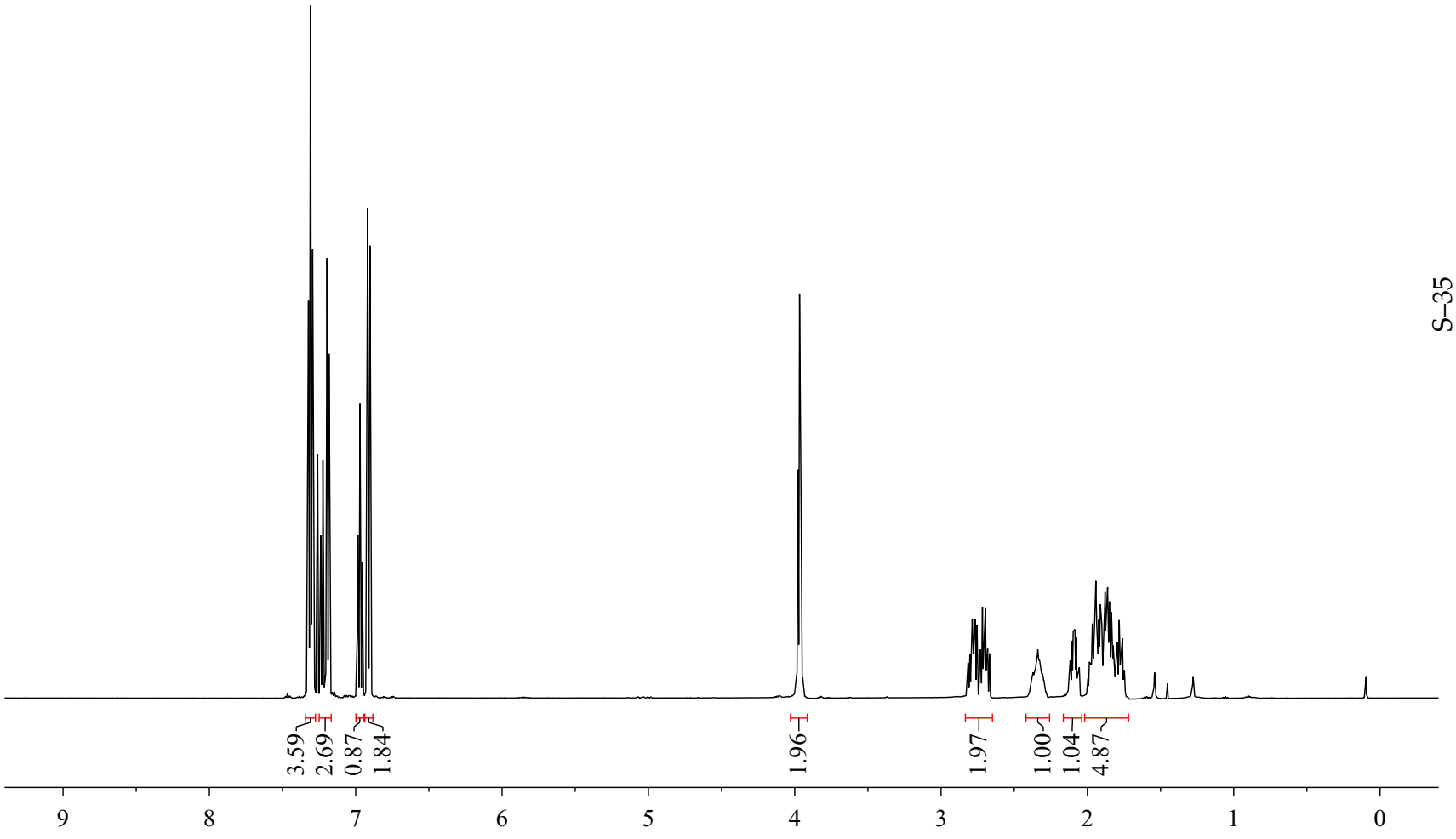


Table 3, Entry 5
($CDCl_3$, 500 MHz)



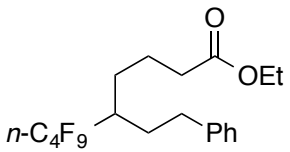
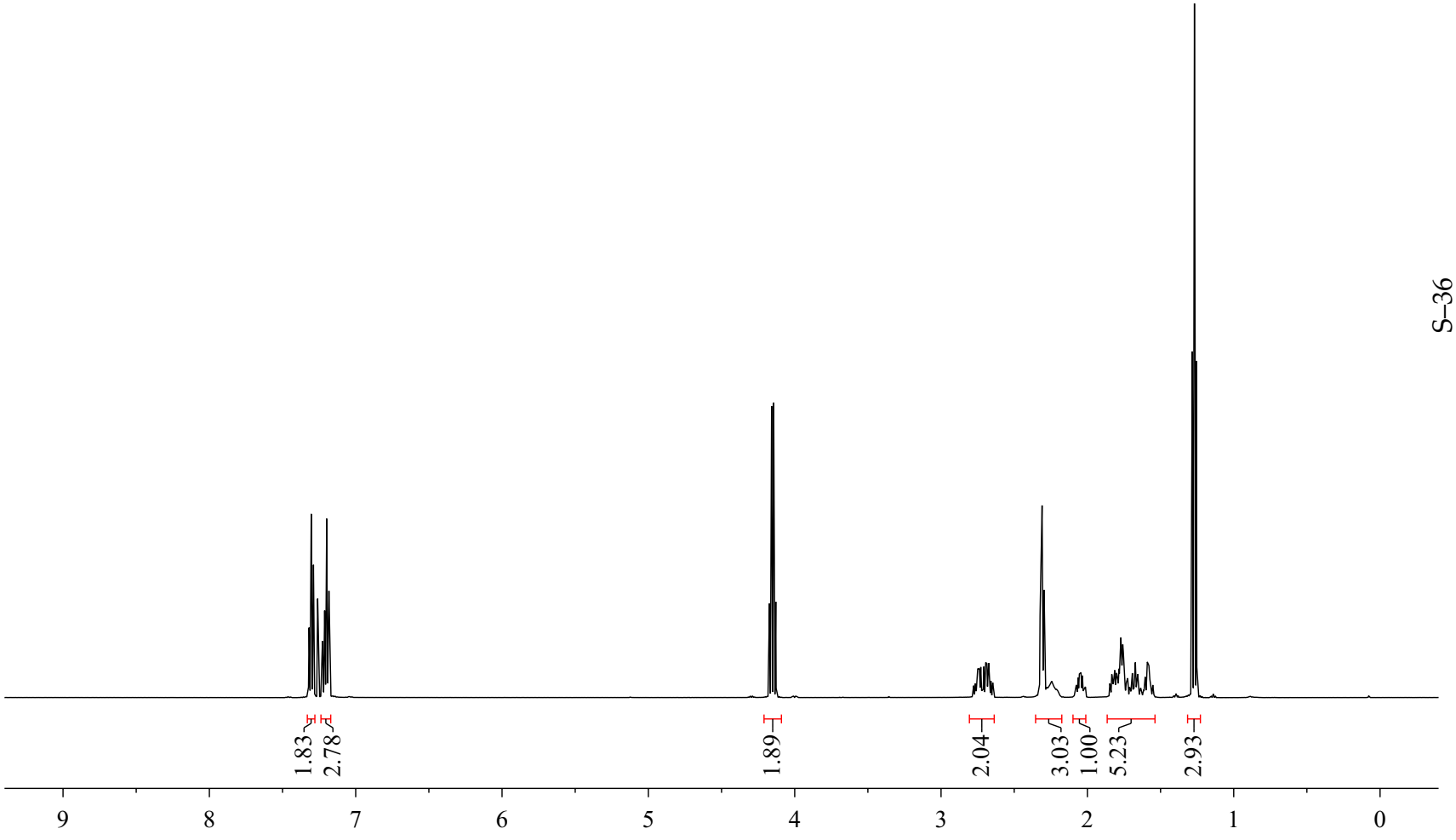


Table 3, Entry 6
($CDCl_3$, 500 MHz)



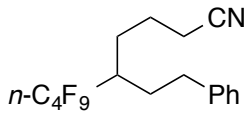
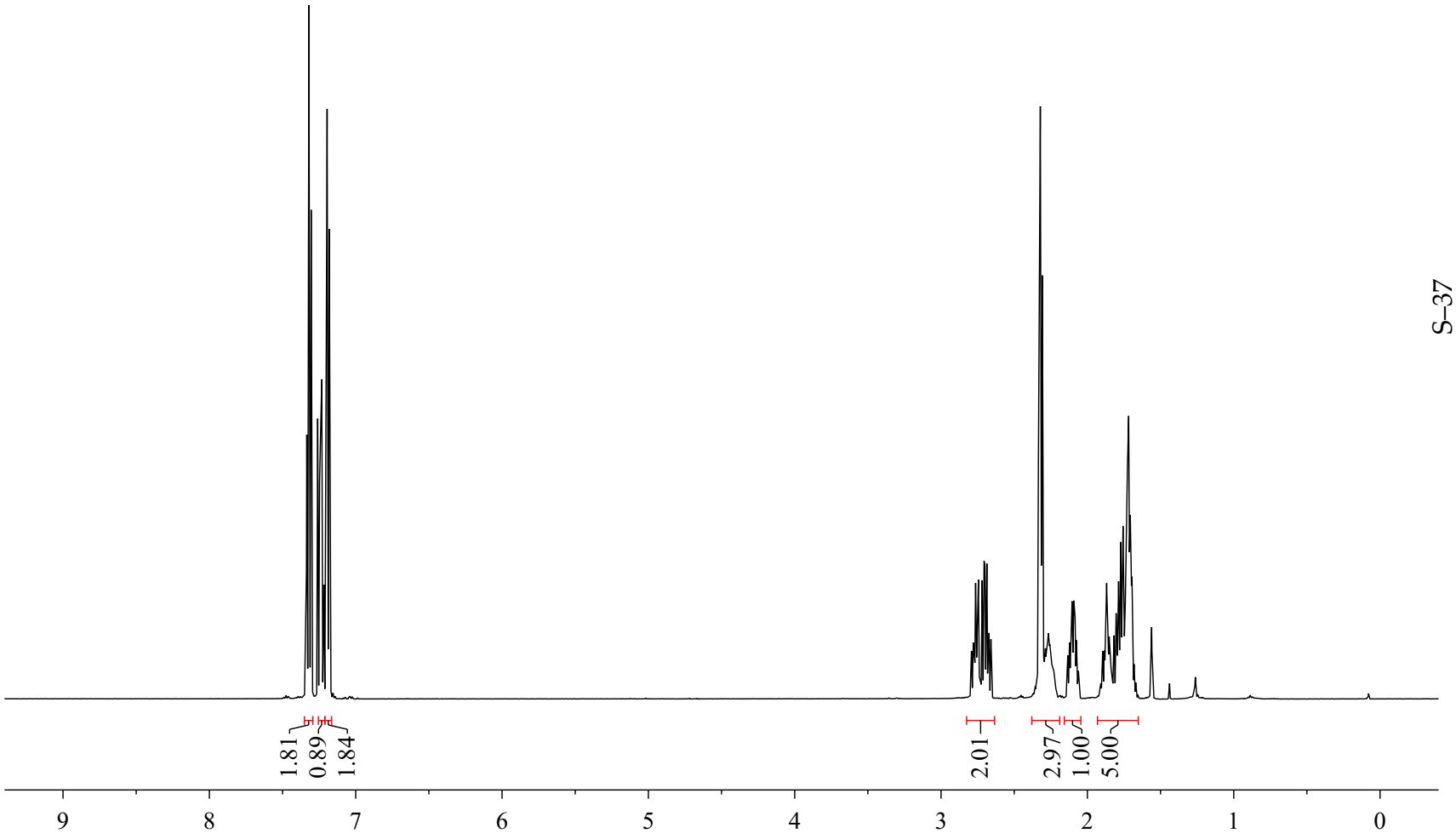


Table 3, Entry 7
($CDCl_3$, 500 MHz)



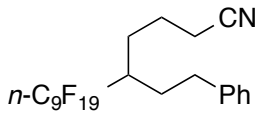
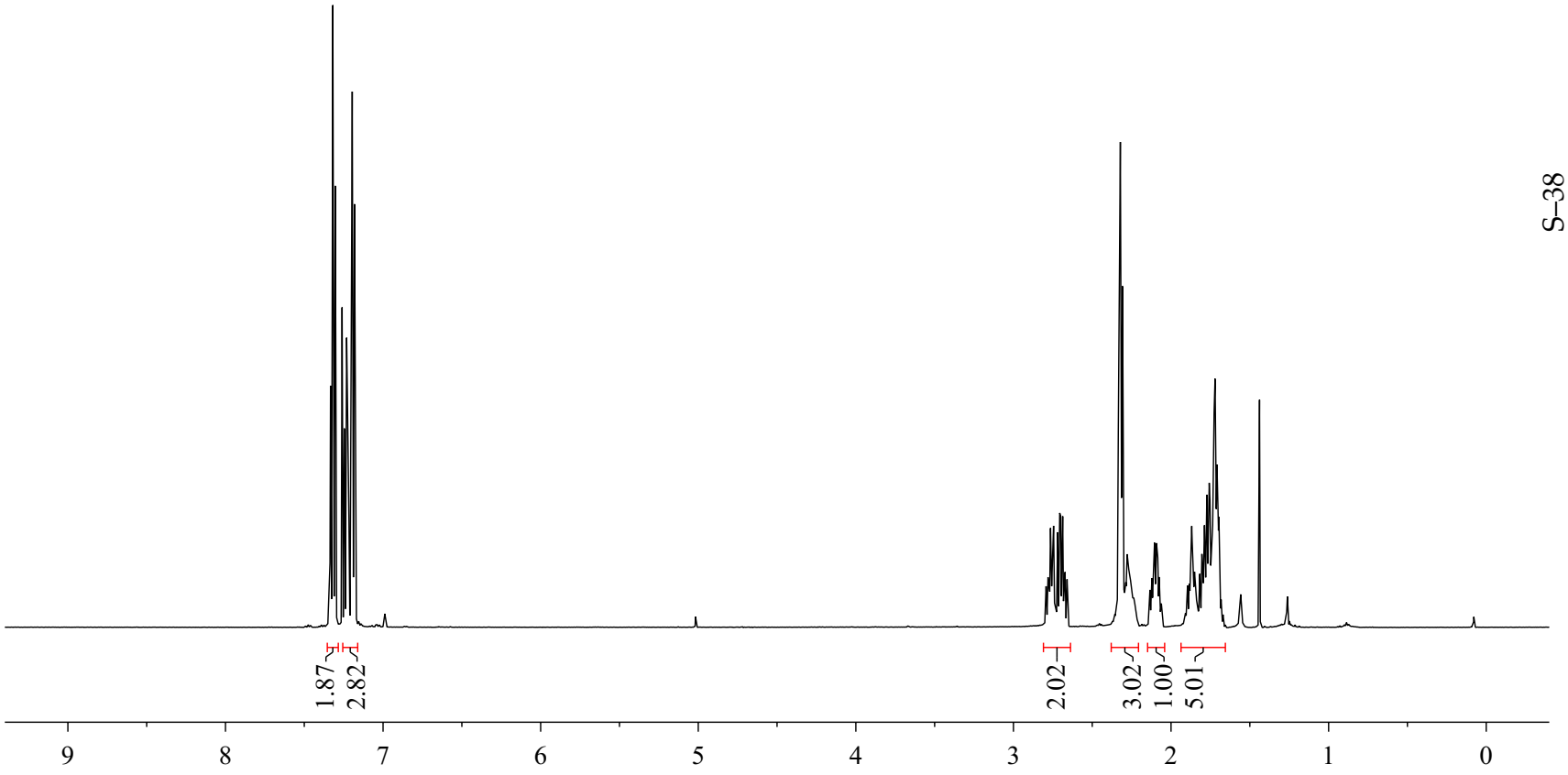


Table 3, Entry 8
($CDCl_3$, 500 MHz)



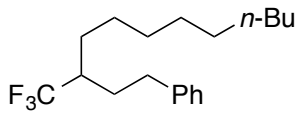
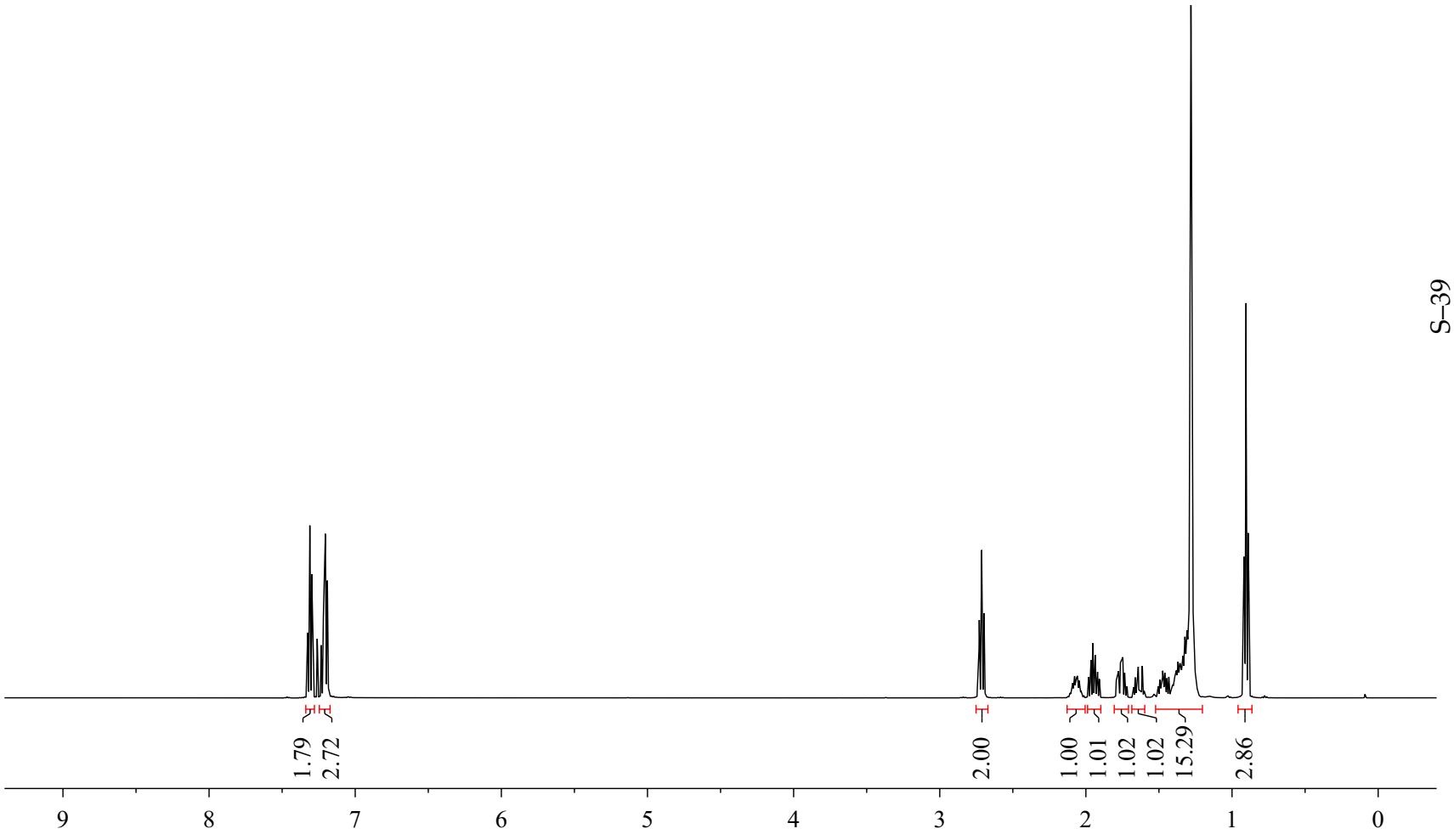


Table 4, Entry 1
($CDCl_3$, 500 MHz)



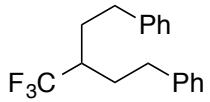
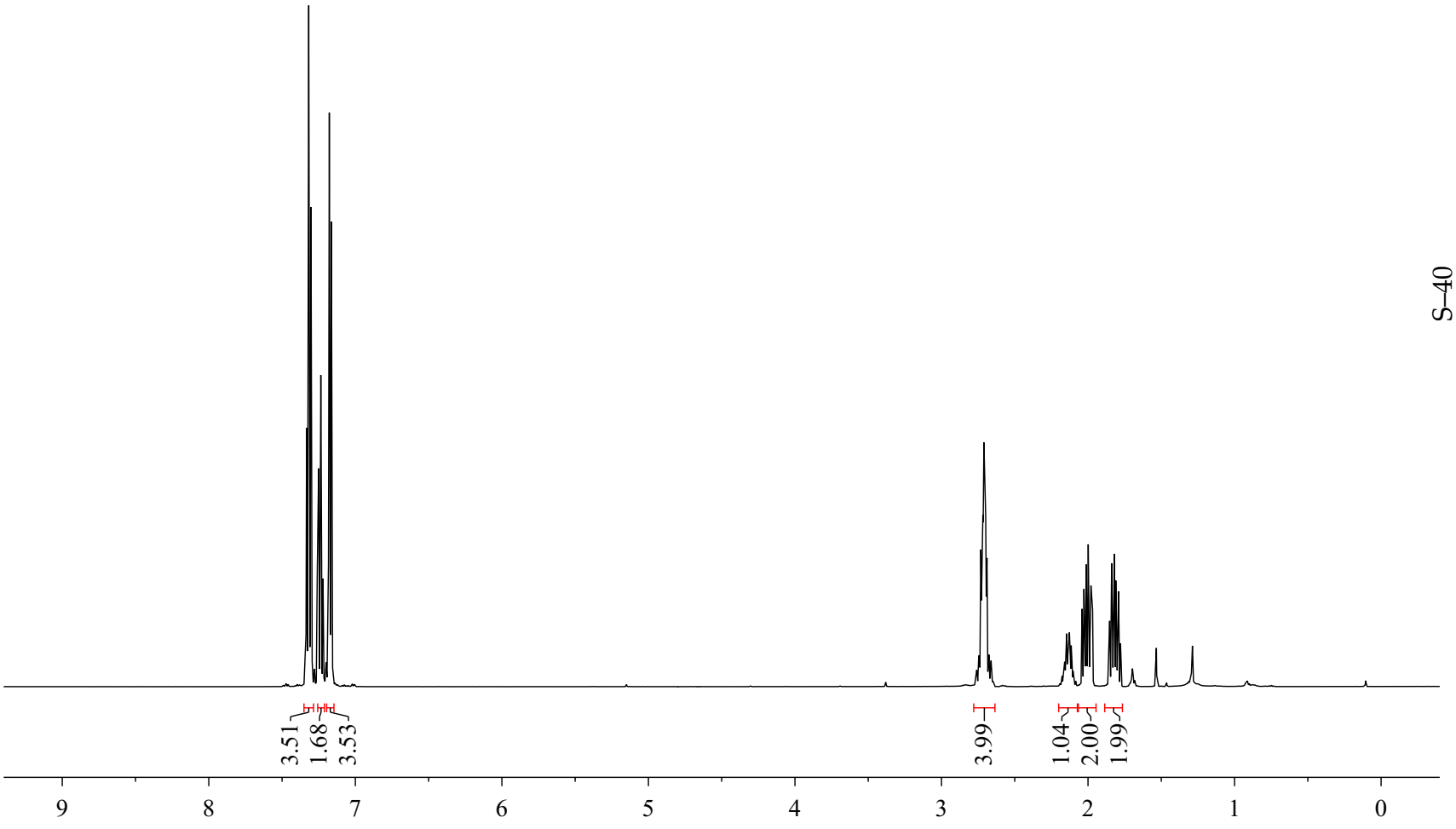


Table 4, Entry 2
($CDCl_3$, 500 MHz)



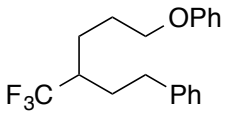
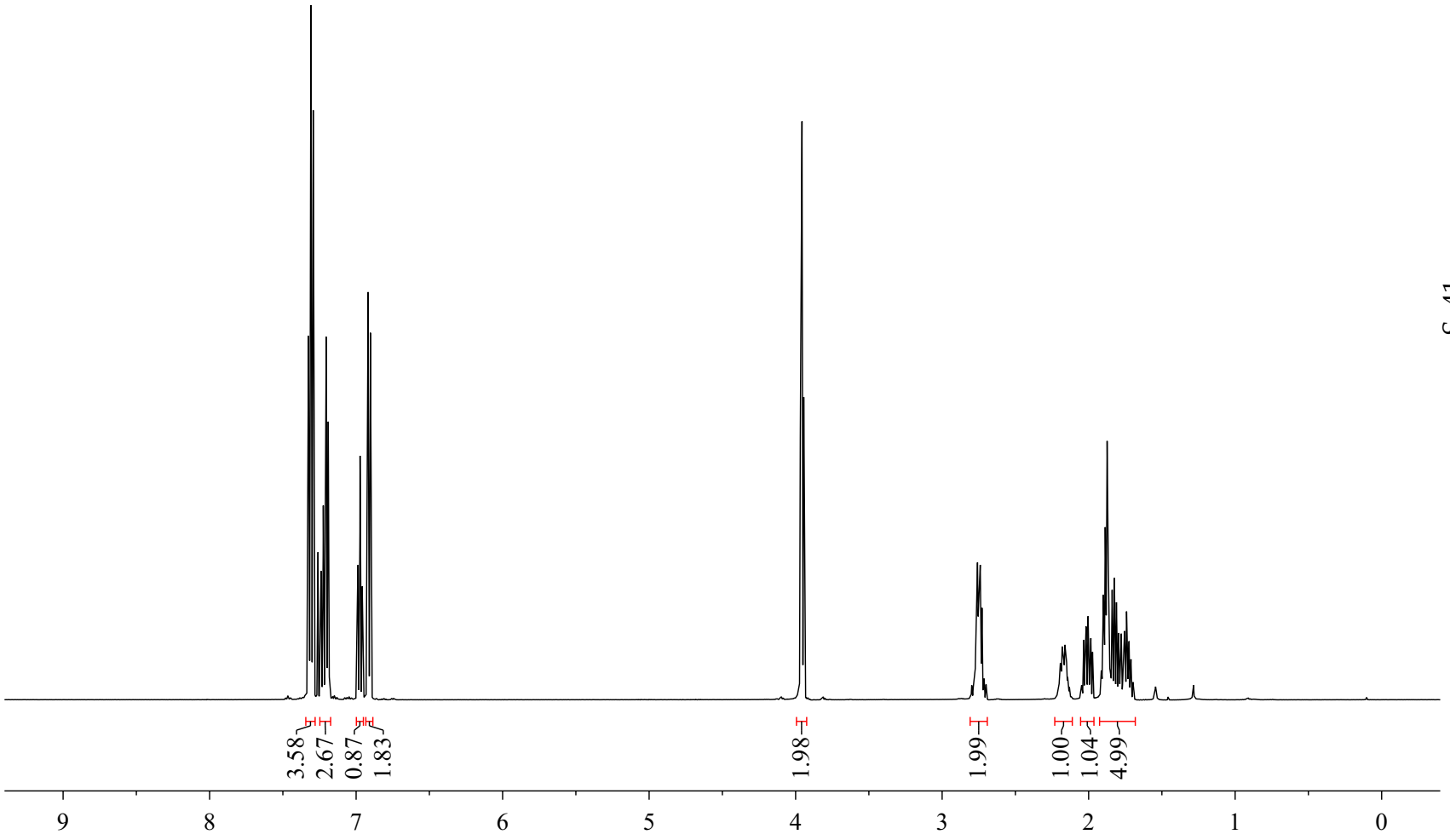


Table 4, Entry 3
($CDCl_3$, 500 MHz)



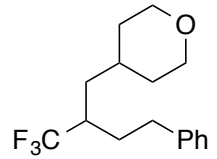
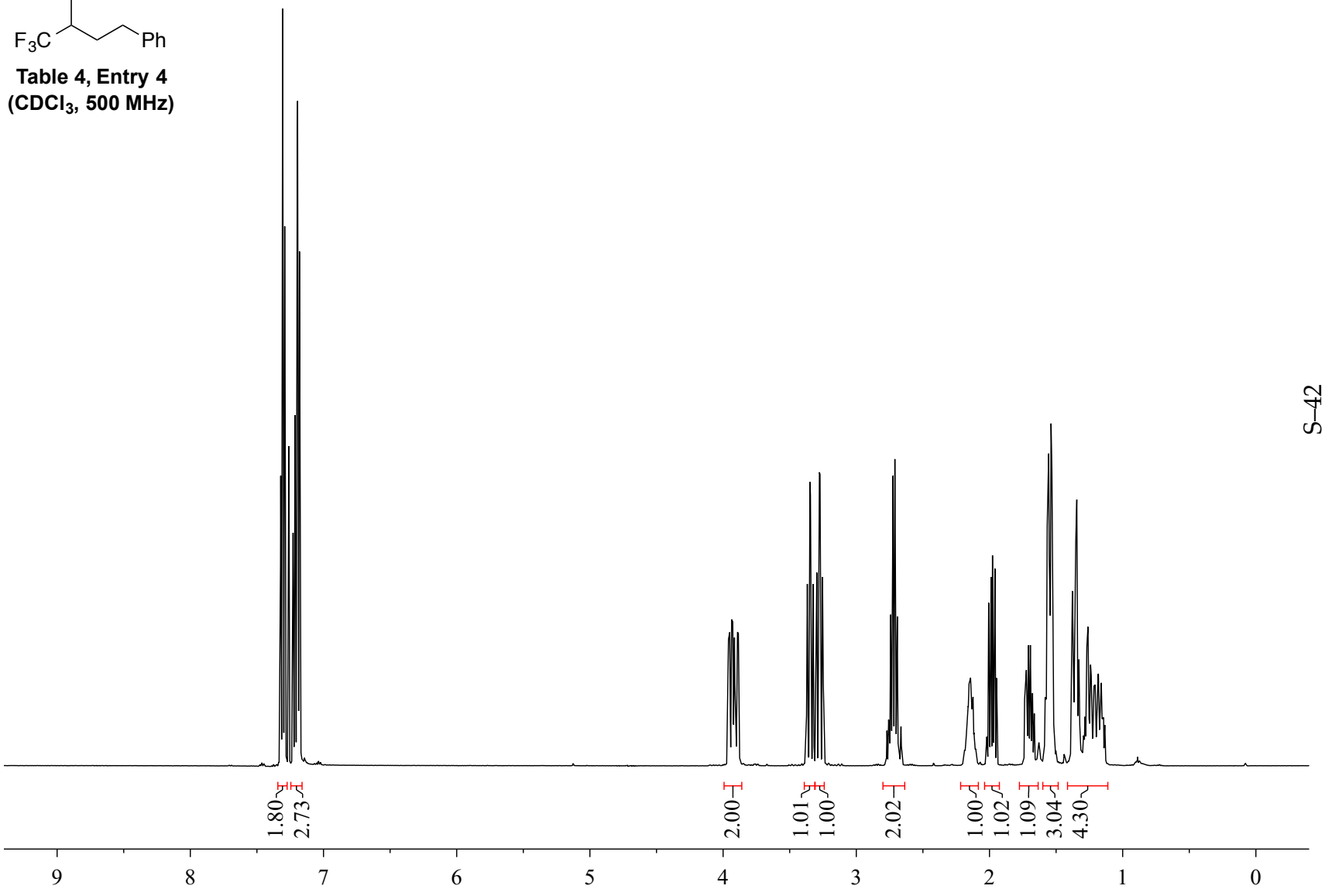


Table 4, Entry 4
($CDCl_3$, 500 MHz)



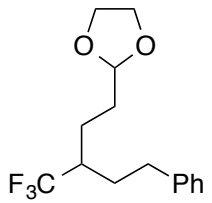
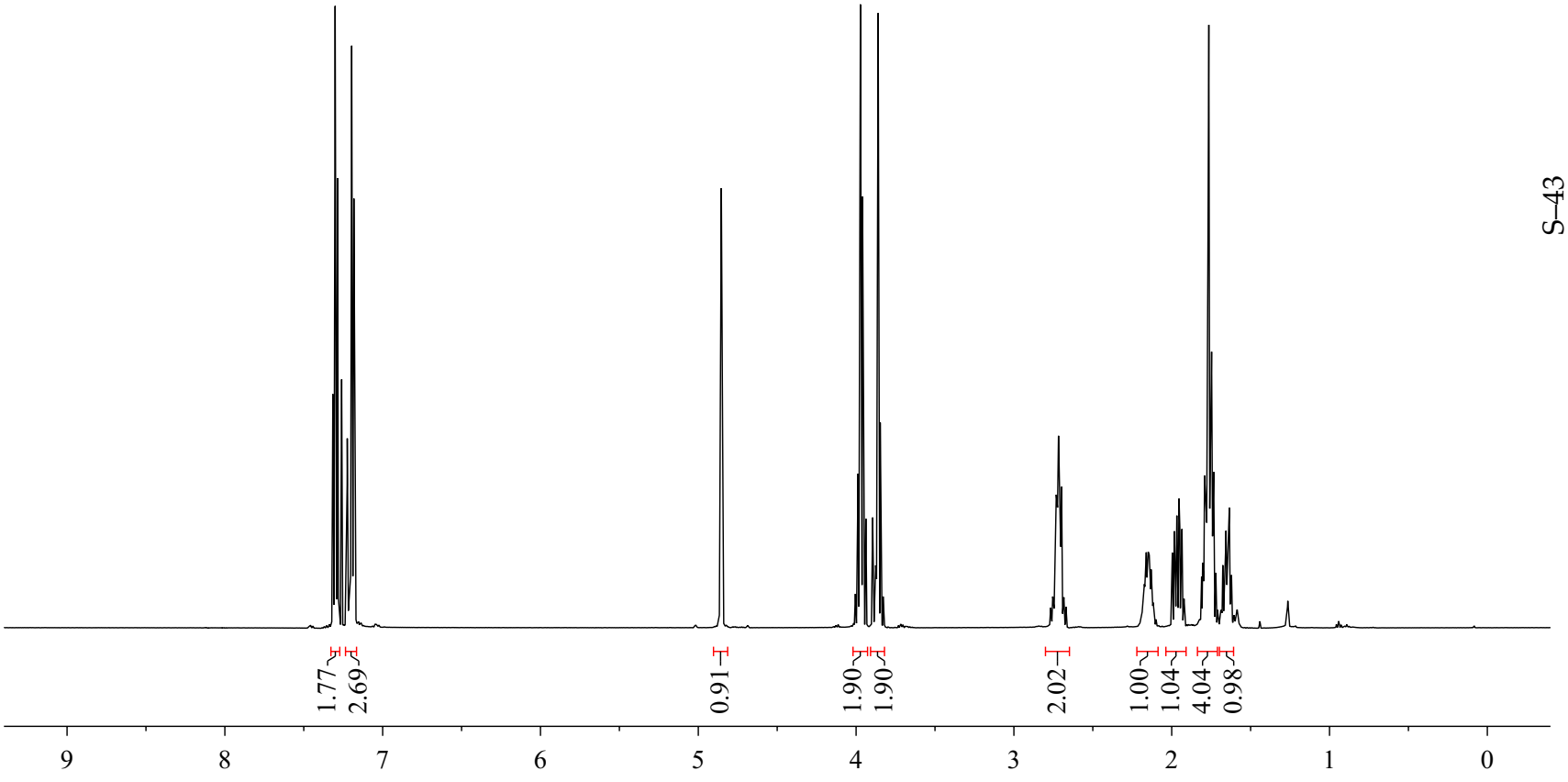


Table 4, Entry 5
($CDCl_3$, 500 MHz)



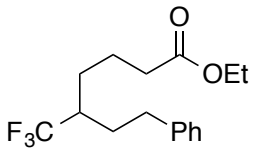


Table 4, Entry 6
($CDCl_3$, 500 MHz)

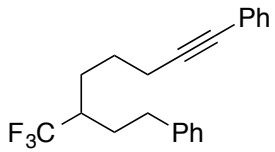
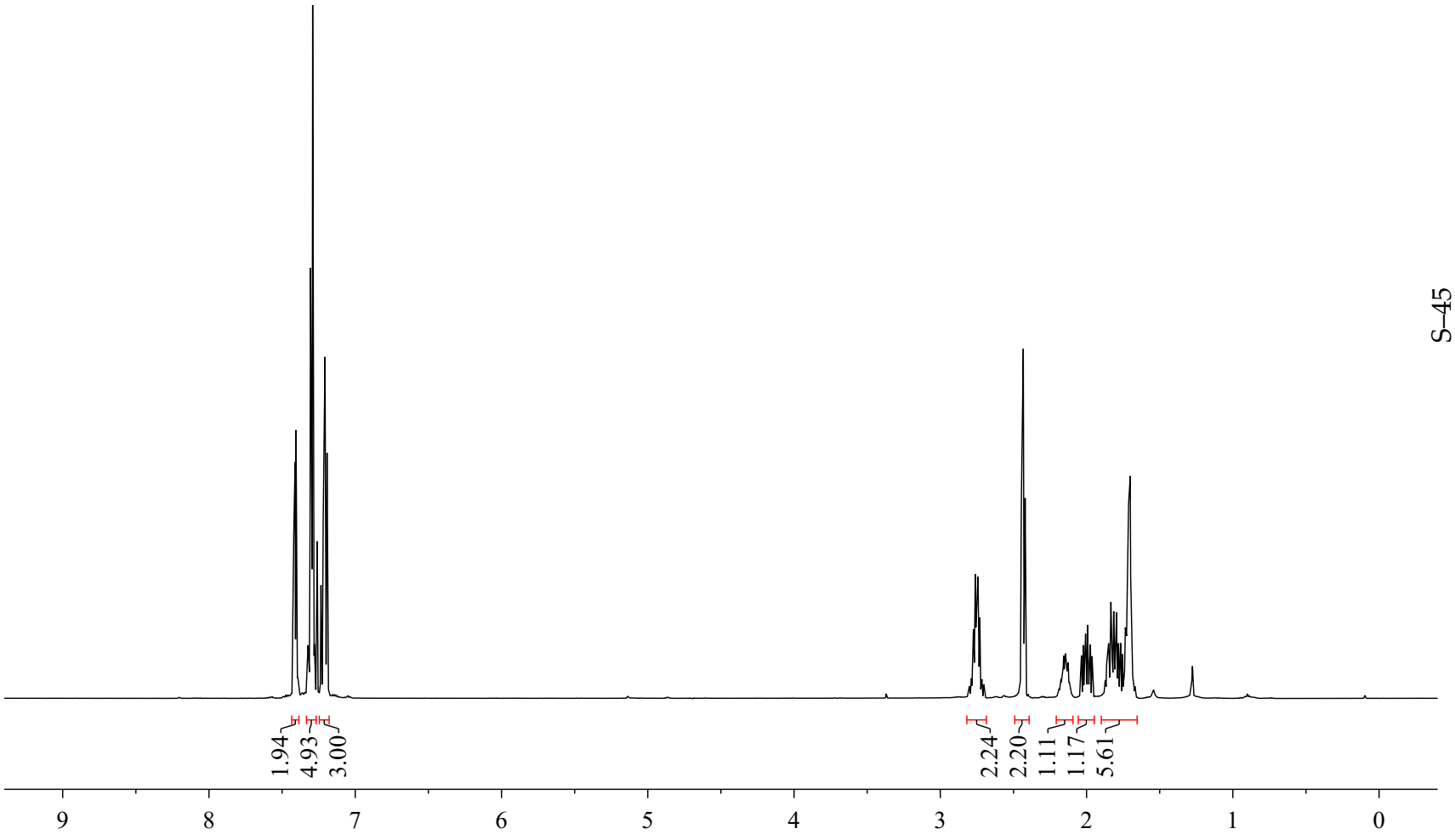


Table 4, Entry 7
($CDCl_3$, 500 MHz)



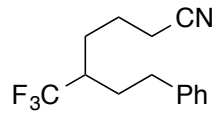
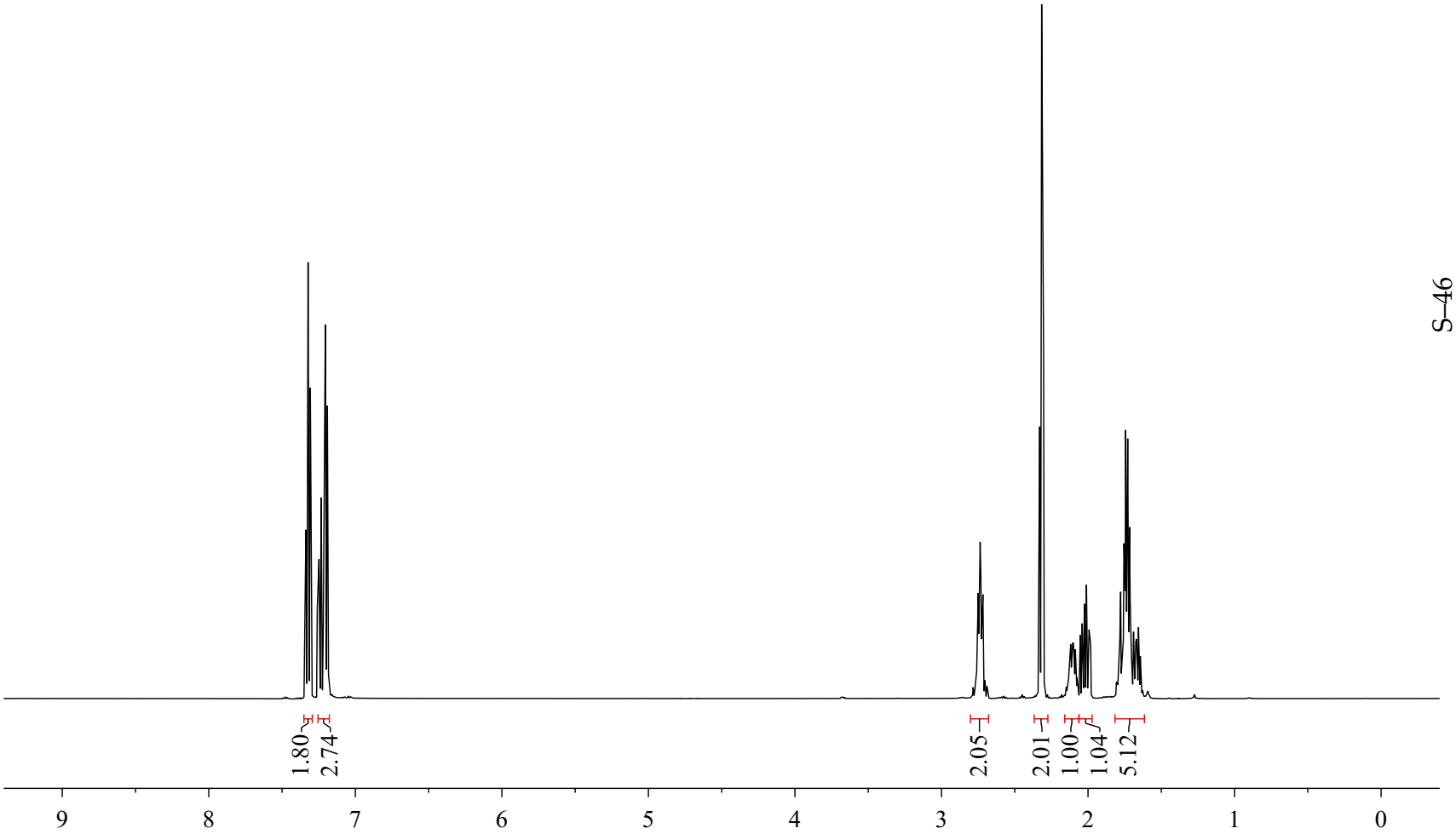


Table 4, Entry 8
($CDCl_3$, 500 MHz)



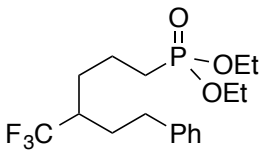


Table 4, Entry 9
($CDCl_3$, 500 MHz)

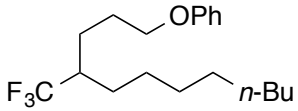


Table 5, Entry 1
($CDCl_3$, 500 MHz)

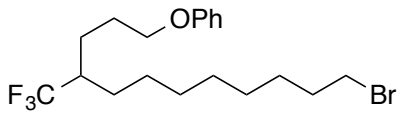
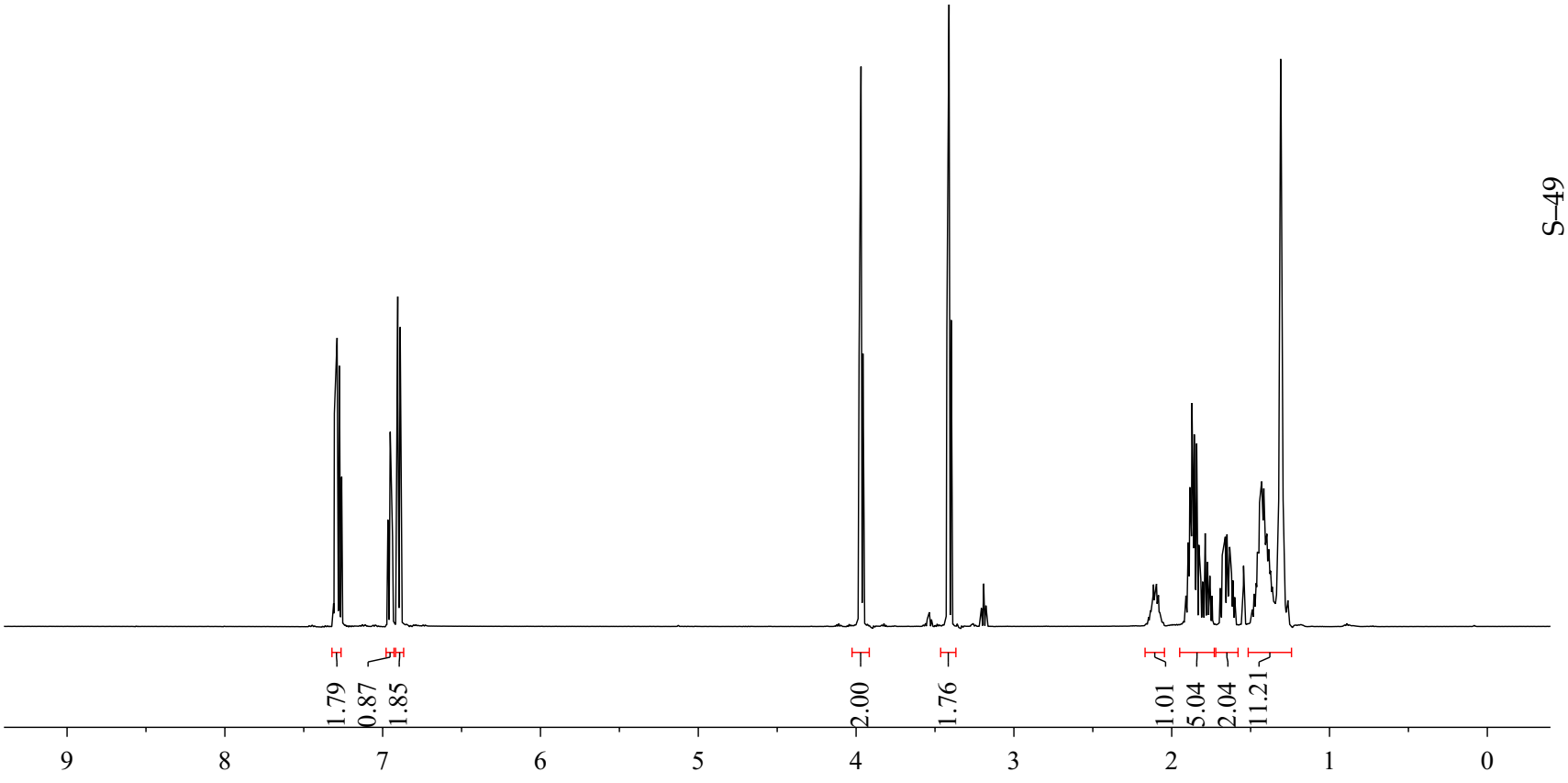


Table 5, Entry 2
($CDCl_3$, 500 MHz)



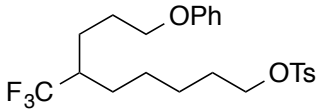
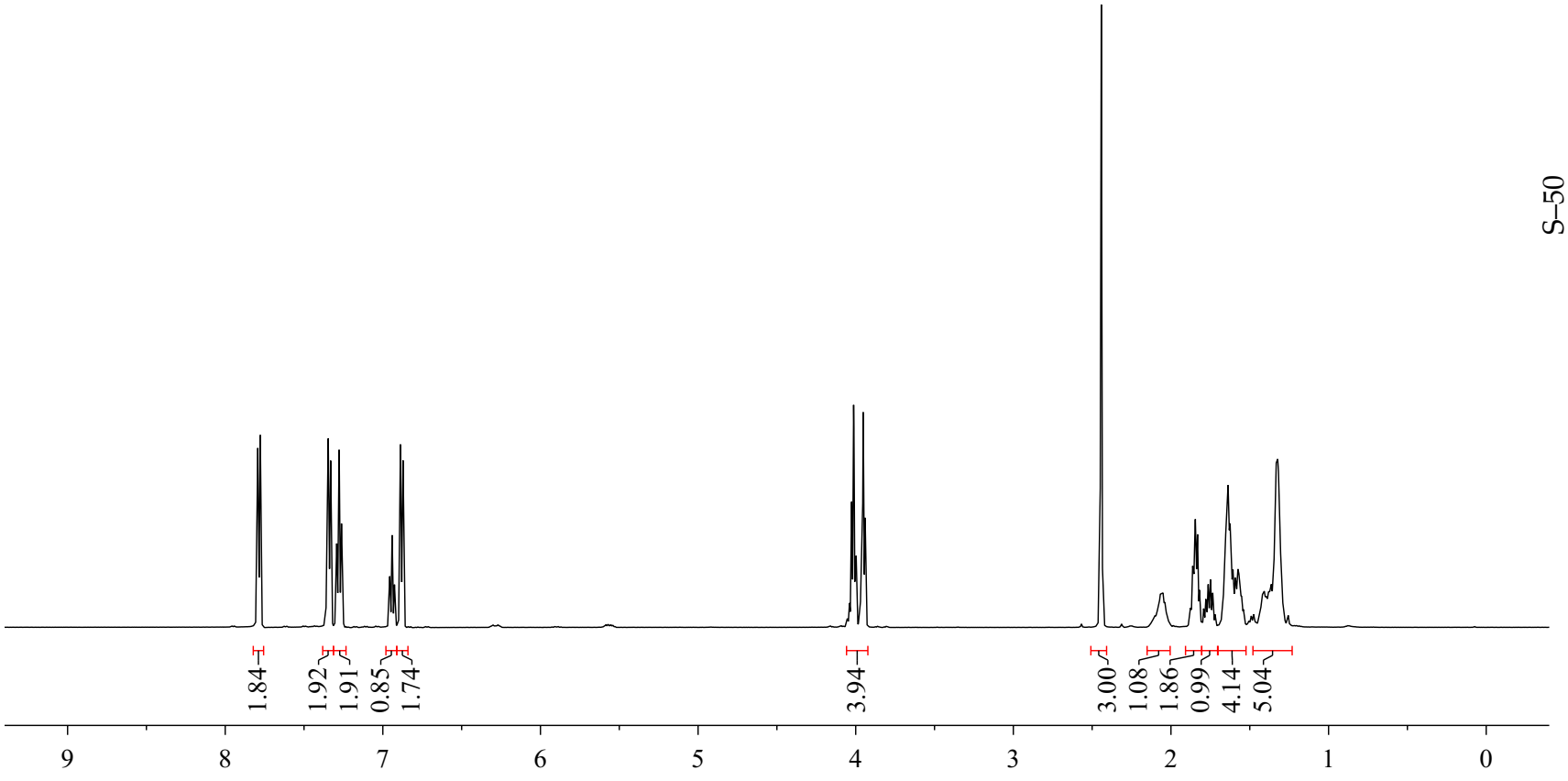


Table 5, Entry 3
($CDCl_3$, 500 MHz)



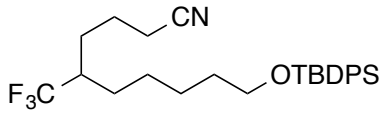
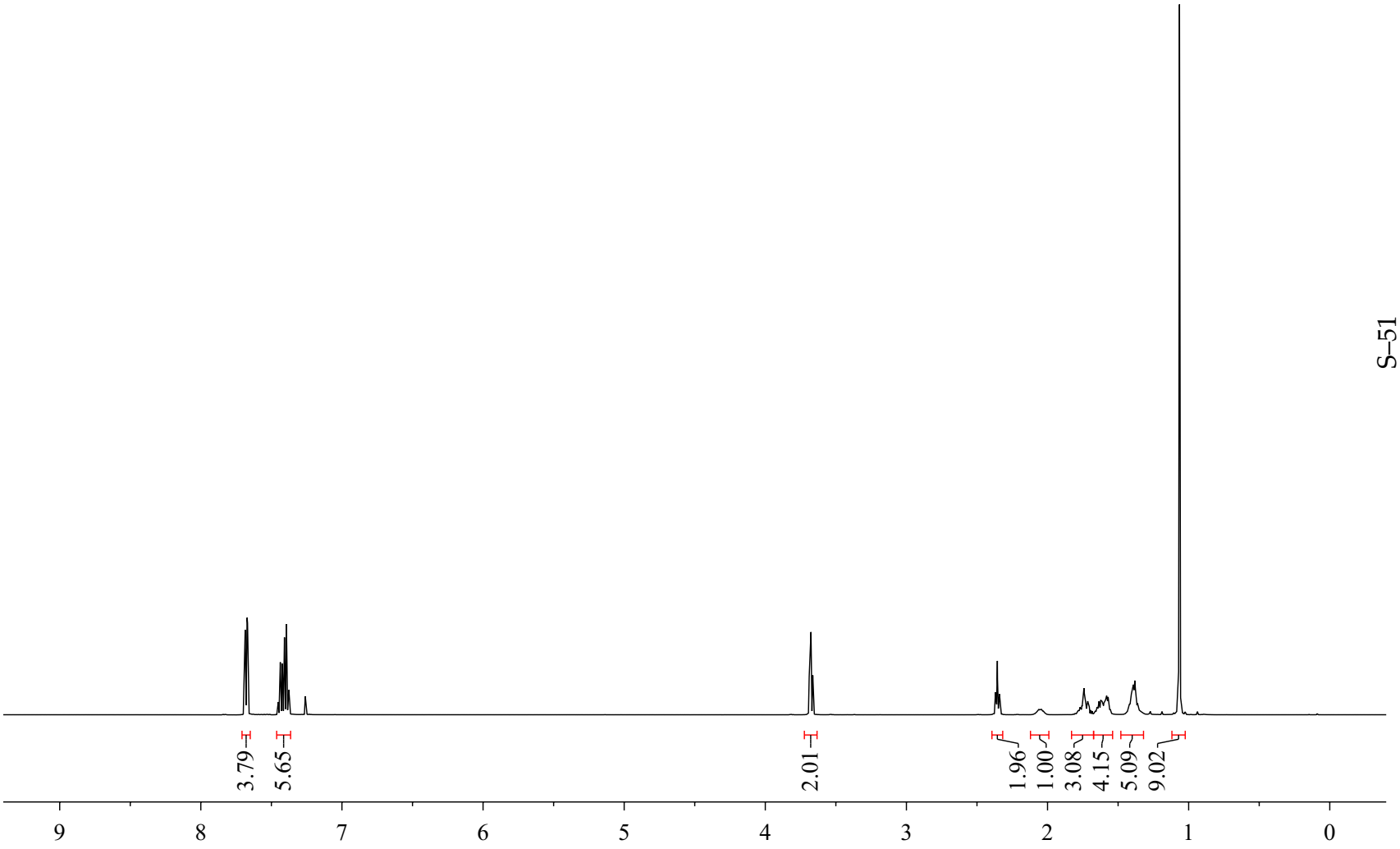


Table 5, Entry 4
($CDCl_3$, 500 MHz)



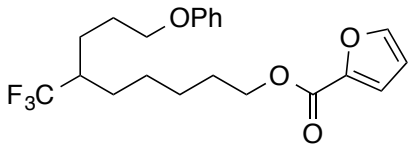


Table 5, Entry 5
(CD_3COCD_3, 500 MHz)

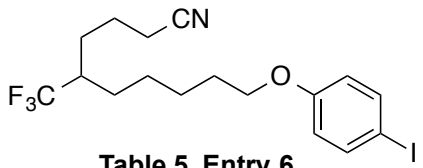
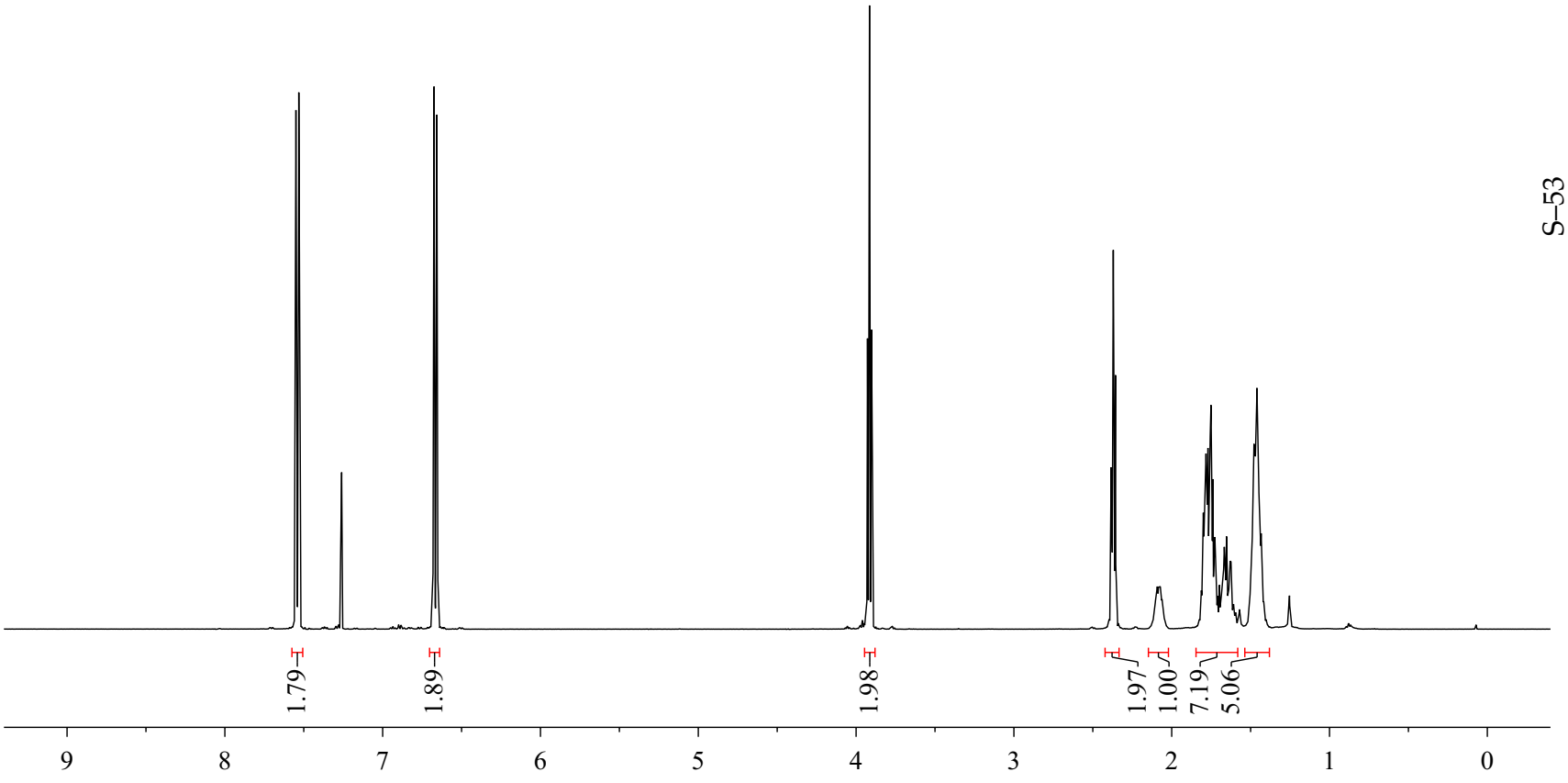


Table 5, Entry 6
($CDCl_3$, 500 MHz)



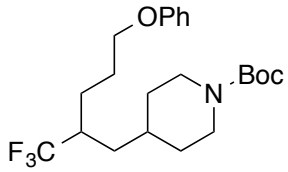


Table 5, Entry 7
($CDCl_3$, 500 MHz)

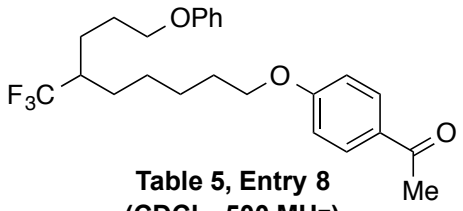
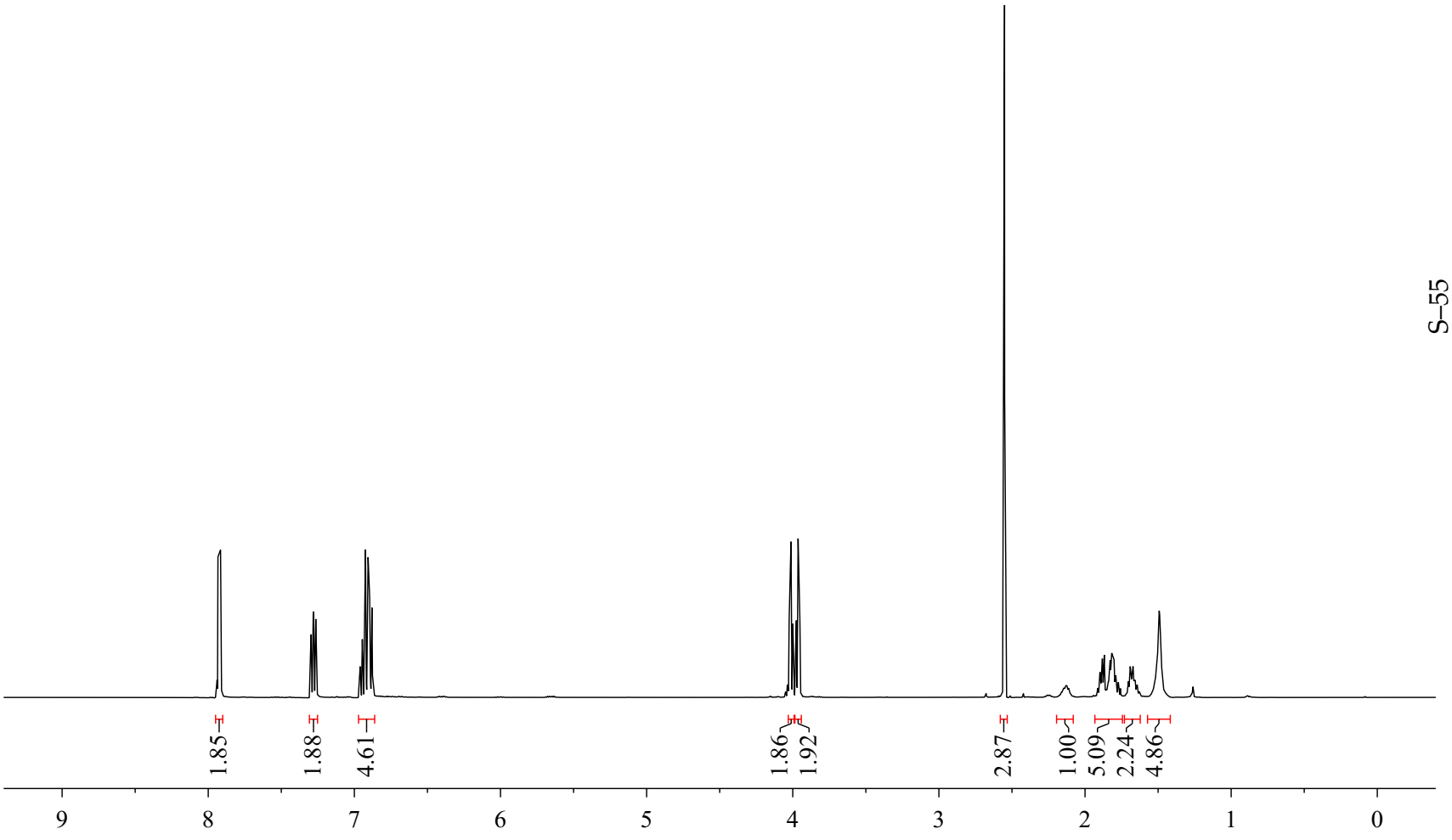
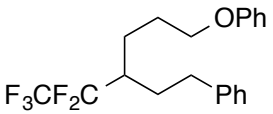
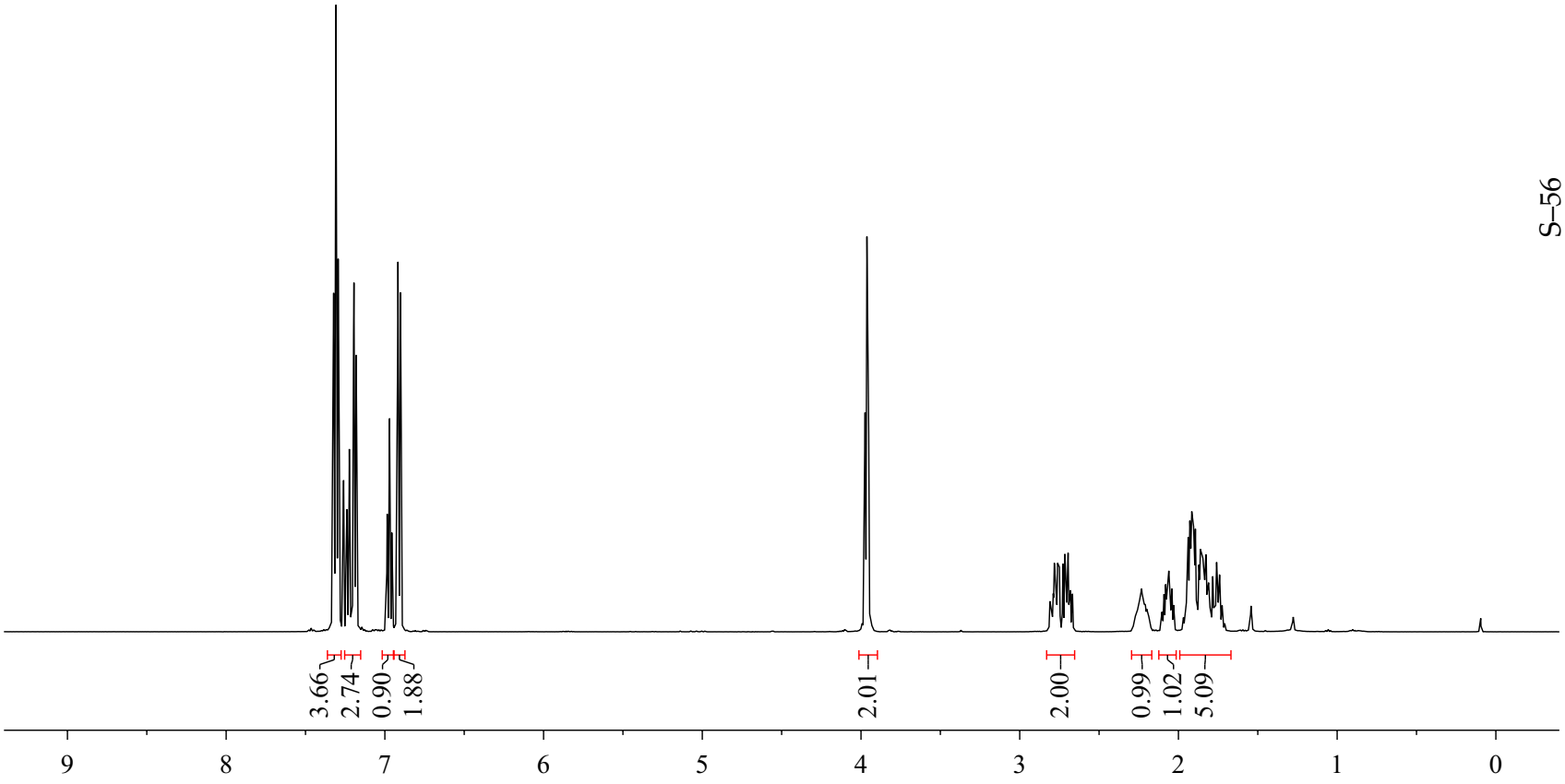


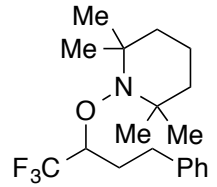
Table 5, Entry 8
($CDCl_3$, 500 MHz)





Eq 5
($CDCl_3$, 500 MHz)





Eq 7
($CDCl_3$, 500 MHz)